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PLUM PACKING COSTS AND EFFICIENCY:

The Effects of Packing Methods and Type of Container

D. G. Stallings (and L. L. Sammet) !

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In Cooperation with MARKETING ECONOMICS RESEARCH DIVISION
AGRICULTURAL MARKETING SERVICE, U.S.D.A.

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FOREWORD

This report presents the results of studies of costs and efficiency in the operation of plants packing California fresh plums. Emphasis is given to the effect of plant size and length of operating season on costs and to determination of the most economical work methods and equipment in each of the major stages of plant operation. The effect of type of container and method of filling on costs is given particular attention.

The study was conducted cooperatively by the Agricultural Experiment Station, University of California, and the Market Organization and Costs Branch of the Marketing Research Division, Agricultural Marketing Service, U. S. Department of Agriculture. It is a contribution to Western Regional Research Project WM-19. Field studies on which the report is based were made in numerous California plum packing houses. This work was coordinated with experimental work on new containers carried on by the California Grape and Tree Fruit League in cooperation with an industry advisory committee and the U. S. Department of Agriculture.

The author is indebted to many members of the industry for cooperation extended in the field studies and in particular to L. L. Sammet and other staff members of the California Experiment Station and the Agricultural Marketing Service for guidance in the study and in the preparation of this report.

PLUM PACKING COSTS AND EFFICIENCY: THE EFFECTS OF PACKING METHODS AND TYPE OF CONTAINER

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PLUM PACKING COSTS IN RELATION TO PACKING METHODS AND TYPE OF CONTAINER

by

Dale G. Stallings[1]

INTRODUCTION

Most California fresh plums are packed in the standard four-basket crate. The container is complex and expensive, and packing labor requirements are high. These circumstances and the small capacity of many individual plants are important aspects of the relatively high costs of packing fresh plums. This study is a contribution to industry efforts to reduce the material and labor costs of these operations. Although it emphasizes the effect of new-type containers and packaging methods on costs, other plant operations are also considered.

Production, Utilization, and Returns in the California Plum Industry

The location and organization of the California plum industry and some of the marketing processes for fresh plums provide a background for the packaging and plant efficiency studies that follow.

Production and Location

California produces over 90 per cent of the commercial output of fresh plums in the United States. Location of production within the state, as well as the usual harvest seasons, are given in Figure 1. Three principal producing areas are indicated. The San Joaquin Valley district (Area 1) contains 46 per cent, the Sierra Nevada foothills district (Area 2) 33 per cent, and the Sacramento Valley district (Area 3) 6 per cent of the total California plum acreage. The remaining acreage is distributed through other parts of the state.

As indicated in Figure 1, maturity is earliest in Area 1, and total season length typically is greatest in this area. The period of peak operations--about five weeks--is roughly the same in all areas.

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[1] Agricultural Economist, Marketing Research Division, Agricultural Marketing Service, U. S. Department of Agriculture and Associate in the Experiment Station, University of California.

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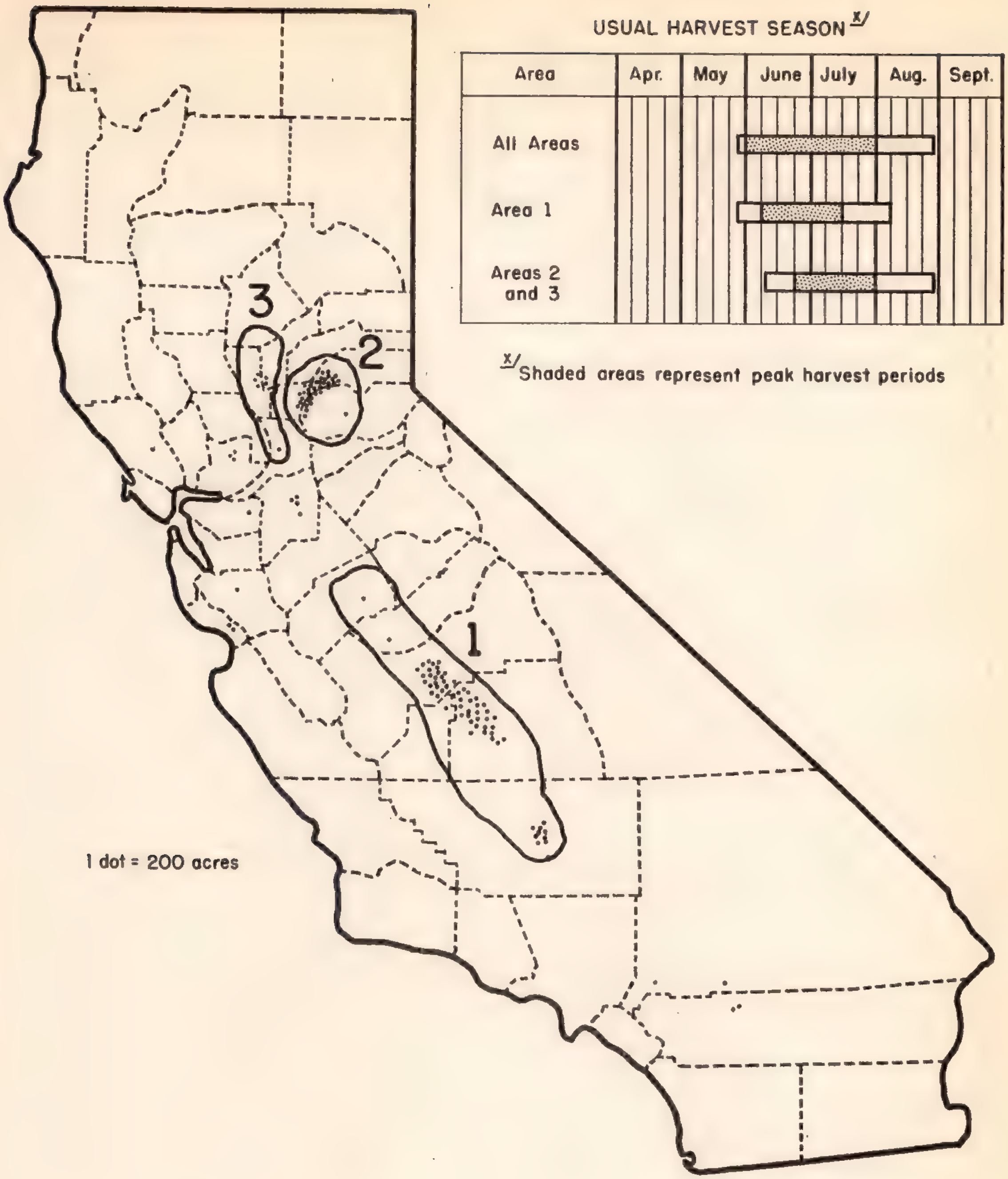

Figure 1. Acreage Distribution and Usual Harvest Season for California Plums, 1953.

Sources:

Rock, Robert C., and A. D. Rizzi, The Where and When of California Fruit and Nut Crops (Berkeley: December, 1955), map 18. (California Agricultural Experiment Station Manual 20.)

California Crop and Livestock Reporting Service, California Fruit and Nut Crops; Acreage, Production, Utilization and Value, 1909-1955 (Sacramento: State Print. Off., July, 1956), pp. 94-97. (U. S. Department of Agriculture, Agricultural Marketing Service, and California Department of Agriculture Special Publication No. 261.)

For the years 1954 to 1956, an average of 4,500 cars per year, containing approximately 1,000 crates per car, were shipped to out-of-state destinations. Of these, 1,700 cars were of the Santa Rosa variety, and 600 were of the Beauty variety, while the Duarte and President varieties accounted for 800 cars. Although these four varieties comprise the major share of the out-of-state movement, shipments of each of 11 other varieties in 1955 exceeded 50 cars. Although harvest volume peaks when the important varieties mature, the large number of varieties maturing at different dates effectively lengthens the packing house operating season.

As shown in Figure 2, Part A, there has been a downward trend in the bearing acreage of plums in the state for all varieties since about 1929. Yield per acre, however, has risen enough to result in a slight upward trend in total annual production during this period.

Utilization

Utilization of fresh California plums in the years 1925 to 1956 is shown in Part B of Figure 2. During this period, about 95 per cent of total annual marketings have been in fresh form. Of the total annual fresh shipments, 80 to 90 per cent were to out-of-state markets, mainly in the East and Midwest. With continued rapid expansion in California population relative to other states, the proportion of plums sold within the state has been increasing. However, the volume shipped to out-of-state markets will remain high.

Growers' Gross Returns

Growers' gross returns per ton at the first delivery point vary considerably depending primarily on the total season volume, national income, and the volume of competing fruits marketed. For most years prior to 1951, the returns to the grower for fresh plums shipped out of state exceeded the returns for those sold within the state, and in some years the difference was considerable. This difference has been diminishing, however, and since 1951 the returns in one market have not been consistently better than the other.

Nature of This Report

This report gives the results of studies of costs and efficiency in the operation of packing plants for fresh plums. Least-cost methods in individual

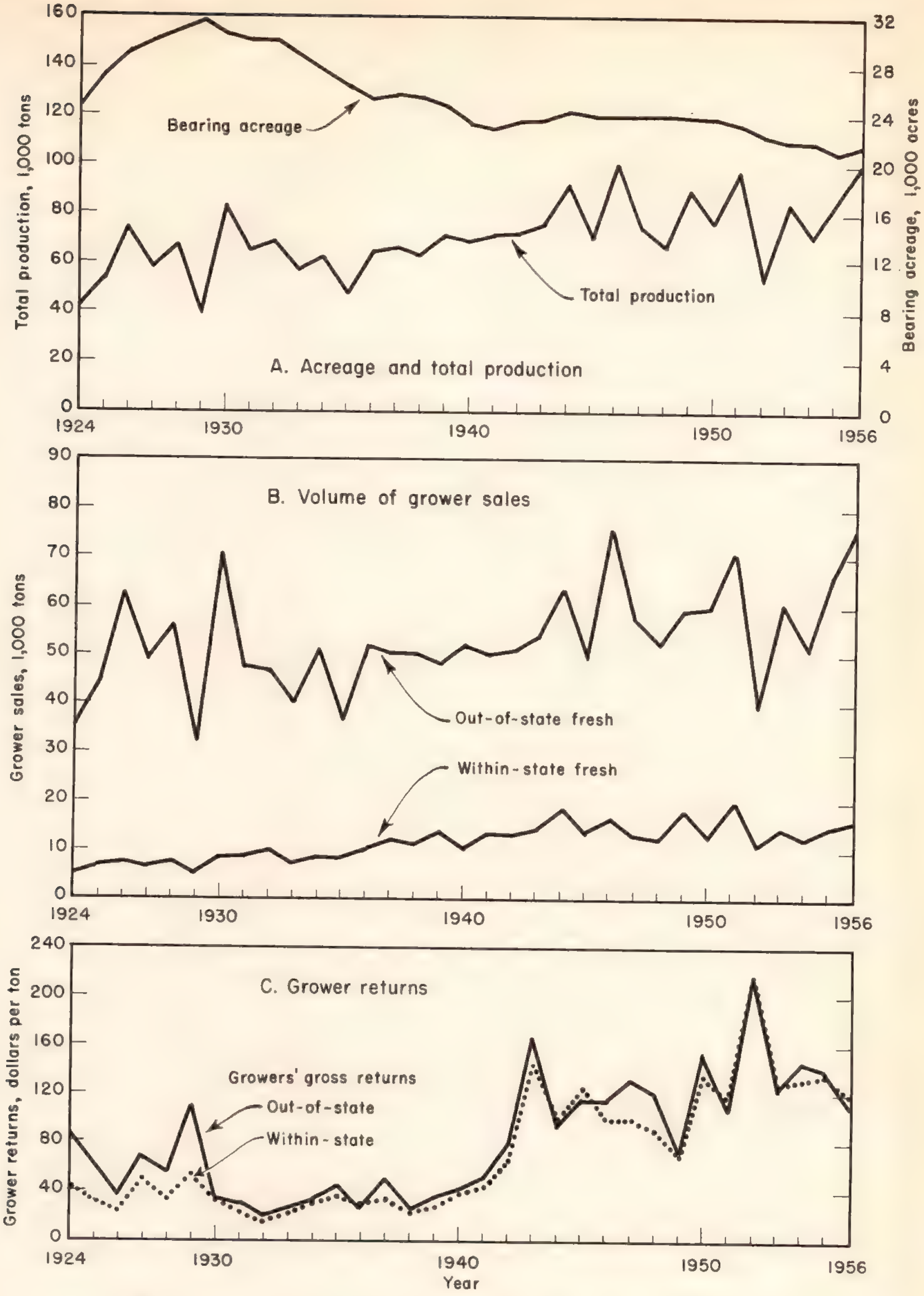

Figure 2. Acreage, Production, Sales, and Grower Gross Returns for Fresh Sales of California Plums, 1924-1956.

Source: California Crop and Livestock Reporting Service, California Fruit and Nut Crops; Acreage, Production, Utilization and Value, 1909-1955 (Sacramento: State Print. Off., July, 1956), pp. 94-97. (U. S. Department of Agriculture, Agricultural Marketing Service, and California Department of Agriculture Special Publication No. 261.)

operations and jobs are determined for varying plant sizes and length of operation per season. Economies of large-scale operation are stressed and special emphasis is given to the effect on costs through the use of three different packaging methods: (1) place packing in the standard four-basket crate; (2) place packing in an experimental carton; and (3) bulk-fill methods of container filling.

Description of Plant Operations

The principal operations performed in plants packing fresh plums include receiving field-run fruit and sorting it into different grades; receiving, assembling, and supplying packages and package materials to the packers; placing fruit in packages according to grade and size; loading the packages of fruit on trucks or railroad cars for shipment to market; and loading cull fruit on highway trucks for disposal. The sequence of these operations and the flow of products and materials in a typical plant are illustrated in Figure 3.

A wide diversity of methods of operation and plant layouts exists in plum packing plants. An arrangement of equipment and floor space involving the selection of commonly used methods is shown in the floor plan, Figure 4.

Method of Analysis and Sources of Data

One of the principal objectives of this report is the estimation of total season costs in relation to output in efficiently organized plants operated at capacity rate. Efficient plants are those using least-cost methods and techniques from among those available.

Comparison of costs with the different methods and types of equipment must take into account the level of both variable and fixed costs with each method in plants of given capacity. In regard to fixed costs, consideration must be given to the total use life and volume of output over which the investment cost may be distributed as well as to other expenses associated with ownership. This is conveniently done in terms of total costs per season, consisting of total season variable costs and an annual fixed charge for equipment. The latter is computed on the basis of a fixed percentage of original investment to cover depreciation, interest, fixed repair, taxes, and insurance. The depreciation allowance is based on estimated physical use life and varies to some extent with type of equipment. Annual cost rates used for the other categories of ownership expense are selected at levels considered to be approximately representative of cost rates experienced in plants of the type under consideration.

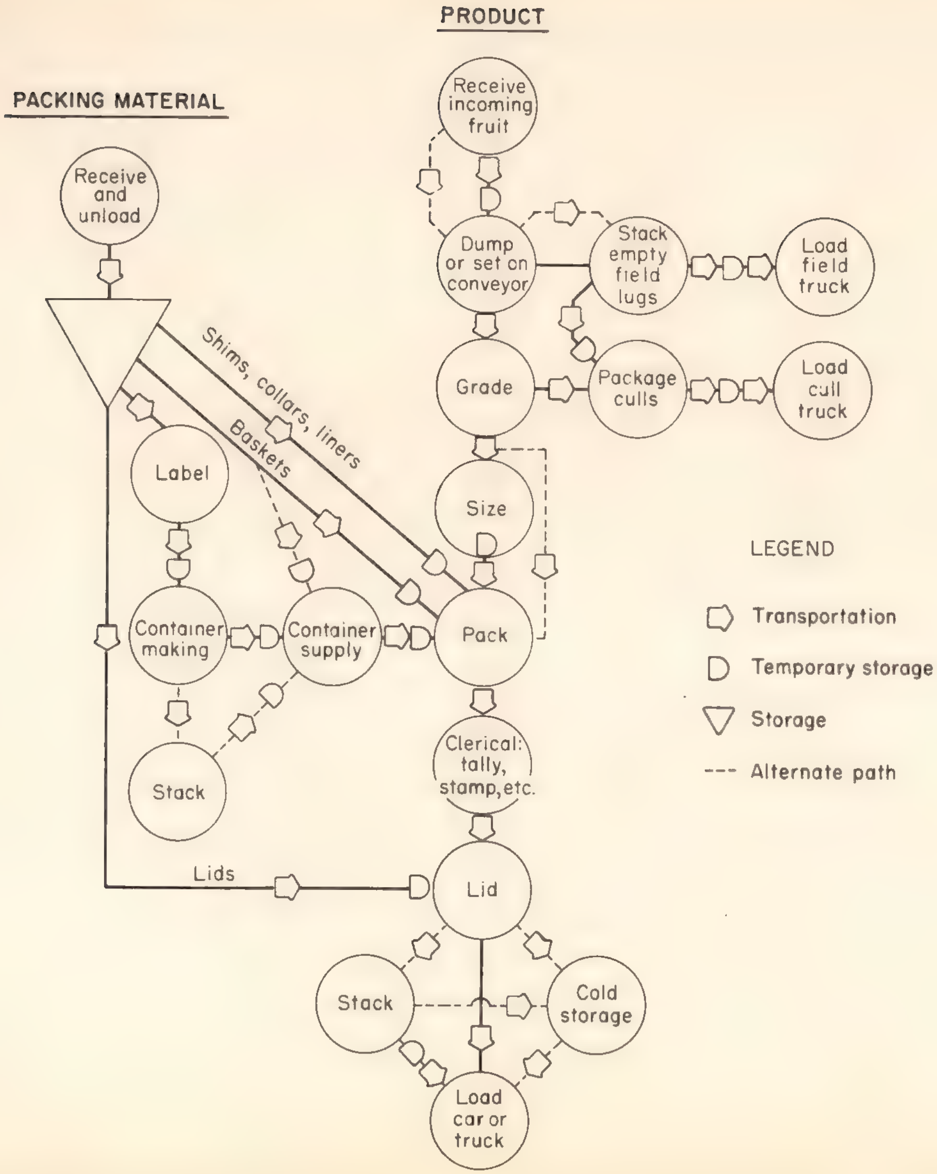

Figure 3. Process Flow Diagram For Plum Packing Plants.

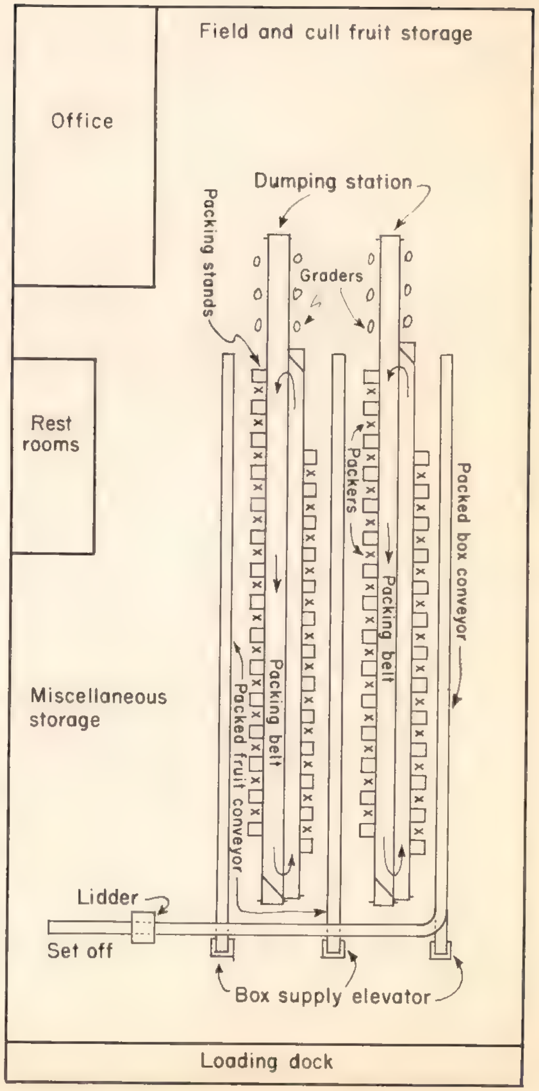

Figure 4. Floor Plan For A Plum Packing Plant With Belt Packing-Lines, Basement Box Supply, And Empty Box Supply Conveyors Beneath The Packed-Fruit Conveyor.

Using the estimated variable and fixed costs, total season costs for selected lengths of season are computed for each alternative method of performing a particular operation. The method which gives the lowest total cost for any specified rate of output is then selected. The procedure of estimating costs for an efficient plant is made easier by grouping the plant operations into a series of plant "stages" composed of closely related operations, where costs in a particular stage can be considered independently of costs in any other stage.

The various elements of cost are related primarily to the use of labor and supervision, equipment, buildings, container materials, and miscellaneous services. Most of the data for estimating quantities required of these factors with different rates of output and methods of operation were obtained in engineering and accounting studies of a sample of packing plants and from data supplied by equipment manufacturers. These data were supplemented with information from earlier studies. Price and wage information for conversion of physical requirements to costs was also obtained from these sources.1/ Wage rates and equipment costs are, of course, an important factor affecting the cost of manual compared with mechanized methods. The cost comparisons and selection of least-cost methods in the following analyses are valid, therefore, only for the wage rates and equipment costs used.

The plants studied included commercial houses and cooperatives packing for several growers as well as smaller ranch-pack operations and included a wide range of plant capacities.2/ In the southern San Joaquin Valley, most of the plants packed grapes as well as plums, and some also packed peaches, nectarines, and other fruits in addition to plums. The plants studied in the Sacramento Valley packed only plums. In the Foothills district, the commercial houses packed pears in addition to plums, while the ranch-pack houses generally packed only plums. Since the costs in this study assume that only plums are packed in the plants, the costs developed may be slightly higher than if some of the items of equipment--such as conveyors, trucks, and cull-handling equipment--or buildings are used jointly to pack other fruit and the fixed costs spread over more units of output.

1/ This method of analysis is described more fully in French, B. C., L. L. Sammet, and R. G. Bressler, "Economic Efficiency in Plant Operations with Special Reference to the Marketing of California Pears," Hilgardia, vol. 24, no. 19, July, 1956, pp. 543-721.

2/ With ranch-pack operations, a single grower or at most a few growers, may pack their own fruit near the orchard or orchards.

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The capacity rate of output in the plants studied ranged from 20 crates per hour in the smallest ranch-pack plant to almost 1,000 crates per hour in the largest commercial plant. The median rate of output was approximately 30 crates per hour in the ranch pack and 280 in the commercial plants. Plant capacities were generally higher in the San Joaquin Valley than in other districts. The hours of operation per season ranged from approximately 180 to 500, with 315 hours as the median value. Hours operated per season were not related to size of plant.

In the analyses which follow, costs are estimated for each of nine operating stages and for four types of general costs. The operating stages include: (1) transportation, (2) dumping, (3) grading, (4) packaging, (5) container making, (6) container supply, (7) direct clerical (such as stamp and tally), (8) container closing, and (9) carloading. The four classes of general costs are: (1) miscellaneous equipment, field lugs and power wiring; (2) direct supervision and miscellaneous labor; (3) building costs; and (4) administrative costs and general operating expense. Aggregation of costs representing efficient stage organization, along with general costs not related to specific operating stages, give total costs for the entire plant.

PLANT STAGE COSTS AND GENERAL COSTS

Analyses of operations and costs with respect to each stage and cost component involved in the estimation of total plant costs are given below. The transportation stage is considered first.

In-Plant Transportation

Much of the work performed in packing house operation involves moving fruit and materials from one point to another. These activities include: (1) receive incoming fruit; (2) transport cull fruit; (3) transport graded fruit to the packers; (4) transport shook and container materials; (5) transport packed fruit; and (6) miscellaneous transportation jobs. Most of these activities can conveniently be considered as part of a transportation stage through which other stages are linked together. However, some types of transportation, such as the distribution of graded fruit and containers to the packers, are performed as an integral part of the packing and container-supply operations and are not included in the transportation stage. Two related jobs required with some but not all

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methods of transportation are included to provide comparability in estimated costs with the various transportation methods. These jobs are the setoff and stacking of packed fruit and the filling and stacking of cull boxes--operations required in transportation with hand trucks and fork trucks, but not with the use of conveyor equipment to transport packed fruit and culls.

Since the proportion of cull fruit affects the costs of some transportation operations, the analysis is carried out with three levels of culling--that is, with the assumption that 10, 20, or 40 per cent of the total fruit run will be separated as cull fruit. The effect on transportation costs if cartons rather than crates are used as the packed-fruit container also is considered, although in this instance detailed analysis is limited to a cull level of 20 per cent of total fruit run.

The analyses are based on the assumption that packed fruit is transported directly to cars for loading. In some plants, however, there is intermediate or temporary storage for precooling or delayed shipment. The effect of this practice on costs is not considered.

Transportation Methods

Two basic methods of in-plant transportation involving the use either of hand- or fork-truck equipment are employed in plum packing houses. In portions of the operations, however, such equipment may be supplemented with powered or gravity conveyors and by gravity chutes. Four different combinations of conveyor and truck operation in the transportation stage--representing different transportation methods--are considered with each type of truck equipment as follows:

Method A: Hand trucks or fork trucks are used for all transportation jobs in this stage. Two other jobs--setoff and stack packed fruit and fill and stack cannery lugs--are also included.

Method B: Hand trucks or fork trucks are used for all work, except the transportation of packed fruit. Conveyor equipment is used for the latter job. The setoff of packed fruit is eliminated, although in the larger plants a conveyor man to route packed fruit to different cars is required. This method also requires a cull man to fill and stack cull boxes.

Method C: Hand trucks or fork trucks are used for all work, except the transportation of culls. A cull conveyor and elevated bin (with gravity delivery to a highway truck) are used in the disposal of culls. Packed fruit must be manually set off and stacked.

Method D: Hand trucks or fork trucks are used for all work except the transportation of packed fruit from lidder to cars and the disposal of culls. Conveyor equipment is used for the latter operations. This eliminates the setoff of packed fruit and the filling and stacking of cull boxes. A conveyor man to route packed containers is required in the larger plants.

These four methods may be used with different types of containers for field fruit, culls, and packed fruit. The transportation of two types of packed fruit containers--the standard crate and the test carton--and one type of container for field fruit and culls is considered. With a given type of container there is, of course, some variation in net weight. With packed fruit, net weights average approximately 28 pounds per standard crate and 25 pounds per test carton. With the field lug, the average net weight when filled with field fruit is approximately 36 pounds, and with culls it is approximately 40 pounds per lug.[1]

Production Standards

The procedure used in estimating labor and equipment requirements in the transportation operations is illustrated by calculations regarding the setoff job performed in the transportation of packed fruit with hand or fork lift trucks. For this operation, time and production studies indicate net time per crate to average approximately 0.129 man-minutes. With an allowance of 15 per cent of the gross time to provide for a minimum of unavoidable delay and scheduled rest periods, estimated gross time is 0.152 man-minutes per crate.[2] This gives a

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[1] The use of two types of containers for field and cull fruit was observed--a grape field lug in the San Joaquin Valley and a pear lug in the Sierra Foothills districts. Compared with an average net weight of 36 pounds of field fruit and 40 pounds of culls per grape lug, the average net weight of pear lugs is 45 pounds for both uses. Based on a hand truck load size of six shorter and deeper lugs, the use of the pear lug results in loads of 270 pounds per trip as compared with 324 pounds per trip with the grape lug. The use of the pear lug thus would require about 20 per cent more trips to handle a given quantity of fruit. Since the receiving and cull-handling operations constitute 50 to 60 per cent of the total in-plant transportation costs, the effect of using pear rather than grape lugs would be to increase the level of costs shown in the analysis by about 10 per cent. The general nature of the results, however, would not be affected.

[2] Scheduled rest periods (two 10-minute periods per 8-hour day) amount to about 4 per cent of the total work time. The remainder of the delay allowance provides for miscellaneous time loss such as personal time, equipment breakdown, and other minor interruptions.

production standard of 395 crates per man-hour. This rate is better than the average actually observed in the plants studied, but does not represent the peak rate observed. An average worker should be capable of this production rate under circumstances which limit idle time to the level allowed in setting the standard.

Production standards for similar jobs in the transport stage--and in other plant stages--are estimated as described above. An exception is in-plant trucking operations which require consideration of the transport distance and the number of containers hauled per trip. Distance and quantity hauled per trip vary with the type of equipment and container used and with the layout in particular plants. The distances and load sizes in relation to type of equipment specified in Table 1 are representative for well-organized plants.[1] They form the basis of estimated quantities of labor and equipment required in the in-plant trucking operations of plants of given capacity output rate. This involves the use of time-distance equations--given in Appendix Table A--to estimate net time per trip with each type of transport and the addition of allowances for unavoidable delay and rest periods (20 per cent of gross trucking time). With time per trip and the number of containers hauled per trip, a production standard for each type of transport may be estimated. Flexibility in trucking job assignments in most plants, however, makes it practicable to estimate trucking requirements on the basis of the total trucking work load rather than with respect to individual transport categories. This is accomplished by estimating the time requirements for each type of transport in terms of a single type of container, in this case the field lug, including an allowance of 10 per cent of total trucking time for several miscellaneous trucking jobs not easily measured directly. The sum of these estimates gives total trucking time.

An example of the estimation of trucking requirements in terms of field lugs run and for 20 per cent culls is as follows. With hand truck equipment, for example, transporting 100 field lugs from the grower's truck requires--with 9 lugs per trip--an average total of 11.11 trips over a one-way distance of 40 feet per trip (Table 1). Using the appropriate time-distance equation for hand truck equipment given in Appendix Table A,

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[1] In Table 1, the effect of plant size on trucking distance per trip is ignored. This is a convenient, but also fairly realistic, simplification. Study of plants of the type involved in this analysis indicates that much of the transport operations involve inward and outward movements of materials (movement at right angles rather than parallel to the building walls) around a center core of floor area containing the packing equipment. The effect of plant size on trucking distance is therefore relatively small.

TABLE 1

Transportation Jobs, Transport Distances, and Size of Load in Representative Hand-Truck and Fork-Truck Plants. Packing California Fresh Plums, 1955

Transportation job	Type of container	Filled container net weight	Average distance transported[a]		Load size per trip			
			Hand truck	Fork truck	Containers		Net weight	
					Hand truck	Fork truck	Hand truck	Fork truck
		pounds	feet		number		pounds	
Receiving[b]								
Unload grower's truck and transport to temporary storage	lug	36	40	80	9	54	324	1,944
Transport full lugs from temporary storage to dumper	lug	36	30	40	9	54	324	1,944
Transport empty lugs from dumper to empty-lug storage	lug	--[c]	60	100	12	66	--	--
Load empty lugs on grower's truck	lug	--	30	40	12	66	--	--
Packed fruit								
Transport from set-off to temporary storage	crate carton	28 25	35 35	35 35	10 8	54 42	280 200	1,512 1,050
Transport from temporary storage to highway truck or rail car	crate carton	28 25	40 40	50 50	10 8	54 42	280 200	1,512 1,050
Cull fruit[b]								
Transport full lugs from cull set-off to temporary storage	lug	40	90	110	9	54	360	2,160
Transport culls from temporary storage to highway truck	lug	40	15	20	9	54	360	2,160
Transport empty cull lug from highway truck to temporary storage	lug	--	80	80	12	66	--	--
Transport empty lug from temporary storage to cull filling station	lug	--	20	40	12	66	--	--
Shook and container materials								
Transport shook and container materials from temporary storage to container maker	bundle	--	40	50	45[d]	225[d]	--	--
Miscellaneous[e]								
Transport lids and pads, unload shook, move pallets, etc.								

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[a] Transport distances for each task are taken as constant. This is based on plant transportation consisting largely of inward and outward movements of materials (movement at right angles rather than parallel to the building walls) around the edges of a "center core" of floor area containing the packing equipment (see Figure 4). Hence, for a wide range in plant capacities, the changes in transport distances are relatively small.

[b] Distances and load sizes are based on plants that use a field lug which is also used to handle grapes during the grape harvesting season.

[c] Dashes indicate not applicable.

[d] Container equivalent of quantity of unassembled container materials transported per trip.

[e] Estimated as 10 per cent of total trucking requirements, exclusive of miscellaneous.

the net time per trip is 0.575 man-minutes. With 20 per cent delay, total time per trip is 0.718 minutes; and for 11.11 trips, the total trucking time in receiving the 100 lugs is 7.98 man-minutes. With a net weight per lug of 36 pounds, the total weight of fruit received per 100 lugs is 3,600 pounds. If culls amount to 20 per cent of total fruit received, the diversion to culls amounts to 720 pounds and the volume packed consists of 2,880 pounds per 100 lugs received. With the data as to net weight and load size given in Table 1, these volume estimates can be converted to number of trips in each type of transport per 100 lugs received. Application of the time-distance equations in Appendix Table A to these results and the addition of allowances for delay and rest periods then provide estimates of time per 100 lugs in each transport category. Computations along the above lines with respect to transportation method A, using hand truck equipment, are summarized below.

Operation	Man-minutes per 100 field lugs with 20 per cent diversion to culls
Receive field fruit	26.78
Transport cull fruit	5.58
Transport packed fruit	14.54
Transport container materials	1.80
Miscellaneous (10 per cent of the above)	4.86
Total time per 100 lugs	53.56

Time requirements and production standards per 100 field lugs received in relation to transportation method used, per cent of culls, and type of packed fruit container are summarized in Table 2. These standards represent the potential truck-transportation output in all transport categories considered as a group, with the standard expressed in terms of field lugs per man-hour with given proportions of cull fruit.

Labor and Equipment Requirements and Costs

Estimates of transportation labor and equipment requirements and their costs in relation to plant size, type of equipment, and transportation method derived

TABLE 2

Time Requirements and Labor Production Standards in the Transportation Stage in Relation to Transportation Method, Per Cent of Cull Fruit, and Type of Packed-Fruit Container. Packing California Plums, 1955

In-plant transportation method and operations	Packed-fruit container[a]	Culls	Gross time per 100 units[b]		Transportation labor standards	
			Hand truck	Fork truck	Hand truck	Fork truck
		per cent	minutes per 100 field lugs		field lugs run per hour	
Truck transportation						
Method A--Hand or fork trucks for all transport categories	crate	10	52.77	16.23	114	370
	crate	20	53.56	16.41	110	366
	crate	40	55.11	16.88	109	355
	carton	20	59.97	18.57	100	323
Method B--Hand or fork trucks for all transport categories except conveyor for packed fruit	[c]	10	34.74	10.94	173	548
	[c]	20	37.58	11.74	160	511
	[c]	40	43.16	13.35	139	449
Method C--Hand or fork trucks for all transport categories except conveyor for culls	crate	10	49.68	15.33	121	391
	crate	20	47.44	14.65	126	410
	crate	40	42.94	13.35	140	449
	carton	20	53.85	16.77	111	358
Method D--Hand or fork trucks for all transport categories except conveyors for packed fruit and culls	[c]	10	31.68	10.04	189	597
	[c]	20	31.46	9.94	191	604
	[c]	40	30.96	9.86	194	608
			minutes per 100 units		units per hour	
Related jobs						
Tend cull station and dump culls[d]	[c]	[e]	51.90	51.90	115 cull lugs	115 cull lugs
Set off packed fruit	crate	[e]	15.20	15.20	395 crates	395 crates
	carton	[e]	12.00	12.00	500 cartons	500 cartons
Conveyor worker	crate	[e]	8.57	8.57	700 crates	700 crates

[a] With some transportation methods and jobs, the type of packed-fruit container affects the production standards.

[b] Includes net working time plus a minimum allowance for rest periods and unavoidable delay of 20 per cent of the gross time.

[c] The type of packed-fruit container does not affect the production standards.

[d] Culls may be dumped into a cull truck before or after the day's operation. For convenience, the time required for this job has been combined with the job of tending the cull station to get a standard for the combined jobs.

[e] The per cent of culls does not affect the production standard in terms of the production units shown.

from the production standards developed above are given in Table 3. The results in Table 3 relate to a 20 per cent culling rate and the use of hand-truck equipment, combined--with some methods--with the use of conveyors for certain operations.

The procedure is easily visualized by tracing the estimation of quantities and costs in regard to method A, in which all transportation is performed with hand-truck equipment. Two related jobs are involved--the setoff of packed fruit; and filling, stacking, and dumping of cull boxes. The production standard for the trucking operations (Table 2) is 110 lugs per man-hour with method A. This means that one trucker will provide trucking services in all transportation categories for plant output rates--measured in terms of the rate of field lugs run--up to 110 field lugs per hour. For output rates in the range of 110 to 220 field lugs per hour, two truckers are required, and so on for still higher rates of output. Similarly, one setoff worker for packed fruit is required with output rates not exceeding 385 field lugs per hour (equivalent to 395 crates per hour at 20 per cent culls), while one cull worker is adequate up to a volume of 640 field lugs per hour. Containers handled per hour in each category are, of course, determined by the number of field boxes run, the per cent of cull fruit, and the net container weights. The output rates at which additions to crew and equipment are required are shown at the left in Table 3. For intermediate rates not shown, the crew requirements are the same as for the next higher capacity output rate.

Crew requirements as developed above then provide a basis for estimating variable and fixed costs. Estimates of variable costs include labor at $1.05 per hour and variable equipment repair expense at 0.5 per cent of equipment replacement cost per 100 hours' use.

Investment in equipment constitutes the fixed costs in this stage. These costs in plants of given capacity rate are estimated in terms of the number of units of each type of equipment required and installed unit prices, including sales and use taxes. With hand-truck equipment, for example, one truck per operator is provided at a unit purchase cost of $90. Requirements as to conveyor equipment used with some of the transportation methods depend on plant layout and plant capacity. The basis of estimation of quantities and prices for this type of equipment are given in Table 3.

Total investment costs and annual charges in relation to plant capacity and transportation method are given in Table 3. Results based on the use of fork- rather than hand-truck equipment are given in Table 4. The results of similar analyses with culling rates of 10 and 40 per cent--rather than 20 per cent applicable in the above development--are given in Appendix Table D.

TABLE 3

Hand Truck Plant Transportation Labor and Equipment Requirements and Costs in Relation to Plant Capacity (Fruit Packed in Crates, 20 Per Cent Culls), Packing California Plums, 1955

Plant capacity		Job and crew size				Variable costs per hour			Fixed costs					Equations of annual fixed cost and variable cost per hour[f]
									Equipment replacement costs[d]					
crates per hour	field lugs per hour	Trucker	Set-off	Conveyor	Tend cull station, dump culls[a]	Labor[b]	Equipment repair and power[c]	Total	Trucks	Packed fruit conveyor	Mechanized cull handling	Total	Annual fixed cost[e]	
		number of workers				dollars								
		Hand truck, Method A												
115	110	1	1	[g]	1	3.15	[h]	3.15	90			90	12	Annual fixed cost = 6 + 11L Variable cost per hour = 2.20 + 1.30L
225	220	2	1		1	4.20	.01	4.21	180			180	24	
340	330	3	1		1	5.25	.01	5.26	270			270	36	
395	385	4	1		1	6.30	.02	6.32	360			360	48	
455	440	4	2		1	7.35	.02	7.37	360			360	48	
565	550	5	2		1	8.40	.02	8.42	450			450	60	
660	640	6	2		1	9.45	.03	9.48	540			540	72	
680	660	6	2		2	10.50	.03	10.53	540			540	72	
790	770	7	2		2	11.55	.03	11.58	630			630	84	
905	880	8	3		2	13.65	.04	13.69	720			720	96	
1,020	990	9	3		2	14.70	.04	14.74	810			810	108	
1,130	1,100	10	3		2	15.75	.05	15.80	900			900	120	
1,190	1,155	11	3		2	16.80	.05	16.85	990			990	132	
1,245	1,210	11	4		2	17.85	.05	17.90	990			990	132	
1,315	1,280	12	4		2	18.90	.05	18.95	1,080			1,080	144	
		Hand truck, Method B--packed fruit conveyor												
165	160	1		1	1	3.15	.11	3.26	90	1,725		1,815	234	Annual fixed cost = 110 + 43L Variable cost per hour = 2.20 + .92L
330	320	2		1	1	4.20	.12	4.32	180	1,725		1,905	246	
495	480	3		1	1	5.25	.12	5.37	270	1,725		1,995	258	
660	640	4		1	1	6.30	.12	6.42	360	1,725		2,085	270	
700	680	5		1	2	8.40	.13	8.53	450	1,725		2,175	282	
825	800	5		2	2	9.45	.24	9.69	450	3,575		4,025	522	
985	960	6		2	2	10.50	.25	10.75	540	3,575		4,115	534	
1,150	1,120	7		2	2	11.55	.25	11.80	630	3,575		4,205	546	
1,315	1,280	8		2	2	12.60	.25	12.85	720	3,575		4,295	558	
1,400	1,360	9		2	2	13.65	.26	13.91	810	3,575		4,385	570	
		Hand truck, Method C--mechanized cull handling												
130	125	1	1			2.10	.19	2.29	90		2,500	2,590	390	Annual fixed cost = 315 + 55L Variable cost per hour = 1.50 + 1.10L
255	250	2	1			3.15	.20	3.35	180		2,500	2,680	400	
280	270	3	1			4.20	.20	4.40	270		2,500	2,770	415	
385	375	3	1			4.20	.24	4.44	270		3,310	3,580	530	
395	385	4	1			5.25	.25	5.50	360		3,310	3,670	540	
515	500	4	2			6.30	.25	6.55	360		3,310	3,670	540	
555	540	5	2			7.35	.25	7.60	450		3,310	3,760	555	
645	625	5	2			7.35	.29	7.64	450		4,115	4,565	665	
770	750	6	2			8.40	.30	8.70	540		4,115	4,655	680	
790	770	7	2			9.45	.30	9.75	630		4,115	4,745	690	
835	810	7	3			10.50	.30	10.80	630		4,115	4,745	690	
900	875	7	3			10.50	.34	10.84	630		4,925	5,555	805	
1,030	1,000	8	3			11.55	.35	11.90	720		4,925	5,645	815	
1,110	1,080	9	3			12.60	.35	12.95	810		4,925	5,735	830	
1,155	1,125	9	3			12.60	.44	13.04	810		6,136	6,946	1,010	
1,190	1,155	10	3			13.65	.45	14.10	900		6,136	7,036	1,020	
1,285	1,250	10	4			14.70	.45	15.15	900		6,136	7,036	1,020	
		Hand truck, Method D--packed fruit conveyor and mechanized cull handling												
195	190	1		1		2.10	.30	2.40	90	1,725	2,500	4,225	610	Annual fixed cost = 445 + 83L Variable cost per hour = 1.55 + .72L
280	270	2		1		3.15	.31	3.46	180	1,725	2,500	4,225	625	
390	380	2		1		3.15	.35	3.50	180	1,725	3,310	5,035	740	
555	540	3		1		4.20	.35	4.55	270	1,725	3,310	5,035	750	
585	570	3		1		4.20	.39	4.59	270	1,725	4,115	5,840	865	
700	680	4		1		5.25	.40	5.65	360	1,725	4,115	5,840	875	
780	760	4		2		6.30	.51	6.81	360	3,575	4,115	7,690	1,115	
835	810	5		2		7.35	.51	7.86	450	3,575	4,115	7,690	1,130	
975	950	5		2		7.35	.55	7.90	450	3,575	4,925	8,500	1,240	
1,110	1,080	6		2		8.40	.56	8.96	540	3,575	4,925	8,500	1,255	

[a] Culls may be dumped into a cull truck before or after the day's operation by a crew of workers. For convenience, the time required for this job has been combined with the job of tending the cull station to get a standard of 115 lugs of culls for the combined jobs. With 20 per cent culls, this is equivalent to a field lug receiving rate of 640 lugs per hour.

[b] Based on wage rate of $1.05 per hour for all workers. These wages include an allowance of approximately 5 per cent of worker's pay for employer's contributions to Social Security, Workmen's Compensation Insurance, and other worker benefits.

[c] Equipment variable repair estimated at 0.5 per cent of replacement cost per 100 hours use and electric power at $0.03 per hour per motor horsepower.

[d] Equipment replacement costs are based on the following equipment requirements. Truck equipment: One truck per operator required. Mechanical cull handling equipment: Cull conveyor--length is 20 feet plus 20 additional feet for each packing line, and width is 1 inch for each 1,000 pounds of culls handled per hour with 8 inches the minimum width; cull elevator--length 20 feet and width same as cull conveyor; and cull bin--volume in cubic feet is 150 minimum plus 100 for each 1,000 pounds of culls handled per hour. Packed fruit conveyor: One drive unit, 90 feet of power conveyor with steel rollers, and 60 feet of gravity conveyor are provided for rates up to 700 crates per hour. Approximately twice this amount is required for rates from 700 to 1,400 crates per hour.

[e] Based on the following percentage charges of replacement cost: Hand truck, power conveyor, and cull bin--13.2 per cent; cull conveyor and elevator--16.5 per cent; and gravity conveyor--11.5 per cent. See Appendix Table C for the details of these charges.

[f] L = plant capacity in 100 field lugs run per hour.

[g] Blanks indicate job not performed with this method.

[h] Less than $0.005.

TABLE 4

Fork Truck Plant Transportation Labor and Equipment Requirements and Costs in Relation to Plant Capacity (Fruit Packed in Crates, 20 Per Cent Culls).
California Fresh Plums, 1955

Plant capacity		Job and crew size				Variable costs per hour			Fixed costs					Equations of annual fixed cost and variable cost per hour[f]
		Trucker	Set off	Conveyor	Tend cull station, dump culls[a]	Labor[b]	Equipment repair, fuel, and power[c]	Total	Equipment replacement costs[d]				Annual fixed cost[e]	
									Trucks	Packed fruit conveyor	Mechanized cull handling	Total		
crates per hour	field lugs per hour	number of workers				dollars								
						Fork truck, Method A								
375	365	1	1	g/	1	3.45	.43	3.88	5,100			5,100	842	Annual fixed cost = 420 + 230L Variable cost per hour = 2.25 + .88L
395	385	2	1		1	4.80	.86	5.66	10,200			10,200	1,683	
660	640	2	2		1	5.85	.86	6.71	10,200			10,200	1,683	
750	730	2	2		2	6.90	.86	7.76	10,200			10,200	1,683	
790	770	3	2		2	8.25	1.29	9.54	15,300			15,300	2,525	
1,125	1,095	3	3		2	9.30	1.29	10.59	15,300			15,300	2,525	
1,190	1,155	4	3		2	10.65	1.72	12.37	20,400			20,400	3,366	
1,315	1,280	4	4		2	11.70	1.72	13.42	20,400			20,400	3,366	
1,500	1,460	4	4		3	12.75	1.72	14.47	20,400			20,400	3,366	
						Fork truck, Method B--packed fruit conveyor								
525	510	1		1	1	3.45	.54	3.99	5,100	1,725		6,825	1,064	Annual fixed cost = 550 + 200L Variable cost per hour = 2.20 + .65L
660	640	2		1	1	4.80	.97	5.77	10,200	1,725		11,925	1,906	
700	680	2		1	2	5.85	.97	6.82	10,200	1,725		11,925	1,906	
1,050	1,020	2		2	2	6.90	1.08	7.98	10,200	3,575		13,775	2,146	
1,315	1,280	3		2	2	8.25	1.51	9.76	15,300	3,575		18,875	2,988	
1,400	1,360	3		2	3	9.30	1.51	10.81	15,300	3,575		18,875	2,988	
1,575	1,530	3		3	3	10.35	1.62	11.97	15,300	5,425		20,725	3,227	
						Fork truck, Method C--mechanized cull handling								
280	270	1	1			2.40	.62	3.02	5,100		2,500	7,600	1,220	Annual fixed cost = 760 + 239L Variable cost per hour = 1.80 + .66L
395	385	1	1			2.40	.66	3.06	5,100		3,310	8,410	1,335	
420	410	1	2			3.45	.66	4.11	5,100		3,310	8,410	1,335	
555	540	2	2			4.80	1.09	5.89	10,200		3,310	13,510	2,175	
790	770	2	2			4.80	1.13	5.93	10,200		4,115	14,315	2,290	
835	810	2	3			5.85	1.13	6.98	10,200		4,115	14,315	2,290	
845	820	2	3			5.85	1.17	7.02	10,200		4,925	15,125	2,405	
1,110	1,080	3	3			7.20	1.60	8.80	15,300		4,925	20,225	3,245	
1,130	1,155	3	3			7.20	1.69	8.89	15,300		6,136	21,436	3,425	
1,265	1,230	3	4			8.25	1.69	9.94	15,300		6,136	21,436	3,425	
						Fork truck, Method D--packed fruit conveyor and mechanized cull handling								
280	270	1		1		2.40	.73	3.13	5,100	1,724	2,500	9,324	1,440	Annual fixed cost = 970 + 200L Variable cost per hour = 1.75 + .47L
555	540	1		1		2.40	.77	3.17	5,100	1,724	3,310	10,134	1,555	
620	605	1		1		2.40	.81	3.21	5,100	1,724	4,115	10,939	1,670	
700	680	2		1		3.75	1.24	4.99	10,200	1,724	4,115	16,039	2,510	
835	810	2		2		4.80	1.35	6.15	10,200	3,574	4,115	17,889	2,750	
1,110	1,080	2		2		4.80	1.39	6.19	10,200	3,574	4,925	18,699	2,865	
1,245	1,210	2		2		4.80	1.48	6.28	10,200	3,574	6,135	19,909	3,045	

a/ Culls may be dumped into a cull truck before or after the day's operation by a crew of workers. For convenience, the time required for this job has been combined with the job of tending the cull station to get a standard of 115 lugs of culls for the combined jobs. At 20 per cent culls, this can be converted to a field lug rate of 640 per hour.

b/ Based on wage rates per hour of $1.35 for fork truck operators and $1.05 for all other workers. These wages include allowance of approximately 5 per cent of worker's pay for employer's contributions to Social Security, Workmen's Compensation Insurance, and other worker benefits.

c/ Equipment variable repair estimated at 0.5 per cent of replacement cost per 100 hours use, fuel and oil at $0.175 per hour per fork truck, and electric power at $0.03 per hour per motor horsepower.

d/ Equipment replacement costs are based on the following equipment requirements. Truck equipment: One truck per truck operator required. Mechanical cull handling equipment: Cull conveyor--length is 20 feet plus 20 additional feet for each packing line, and width is 1 inch for each 1,000 pounds of culls handled per hour with 8 inches the minimum width; cull elevator--length 20 feet and width same as cull conveyor; and cull bin--volume in cubic feet is 150 minimum plus 100 for each 1,000 pounds of culls handled per hour. Packed fruit conveyor: One drive unit, 90 feet of power conveyor with steel rollers, and 60 feet of gravity conveyor are provided for rates up to 700 crates per hour. Approximately twice this amount is required for rates from 700 to 1,400 crates per hour.

e/ Based on the following percentage charges of replacement cost: Fork truck, cull conveyor, and elevator--16.5 per cent; power conveyor and cull bin--13.2 per cent; and gravity conveyor--11.5 per cent. See Appendix Table C for the details of these charges.

f/ L = plant capacity in 100 field lugs run per hour.

g/ Blanks indicate this job or type of equipment not used with this method.

Total Season Cost

Estimated total season costs required in the comparison of different transportation methods are computed from the data in Tables 3 and 4. This may be done directly on the basis of estimated variable and annual fixed costs at particular output rates. With hand truck method **A** and an output rate of 600 field lugs per hour, for example, the estimated variable cost--as given for the output range, 550 to 640 field lugs per hour--is $9.48 per hour and the annual fixed charge is $72. In a season of 100 hours' operation, estimated total season cost would be $1,020, with 300 hours' operation per season it would be $2,916, and so on for other lengths of season. Similar computations at other output rates and with other transportation methods provides a basis for selection of the least-cost transportation method in relation to rate of output and length of operating season.

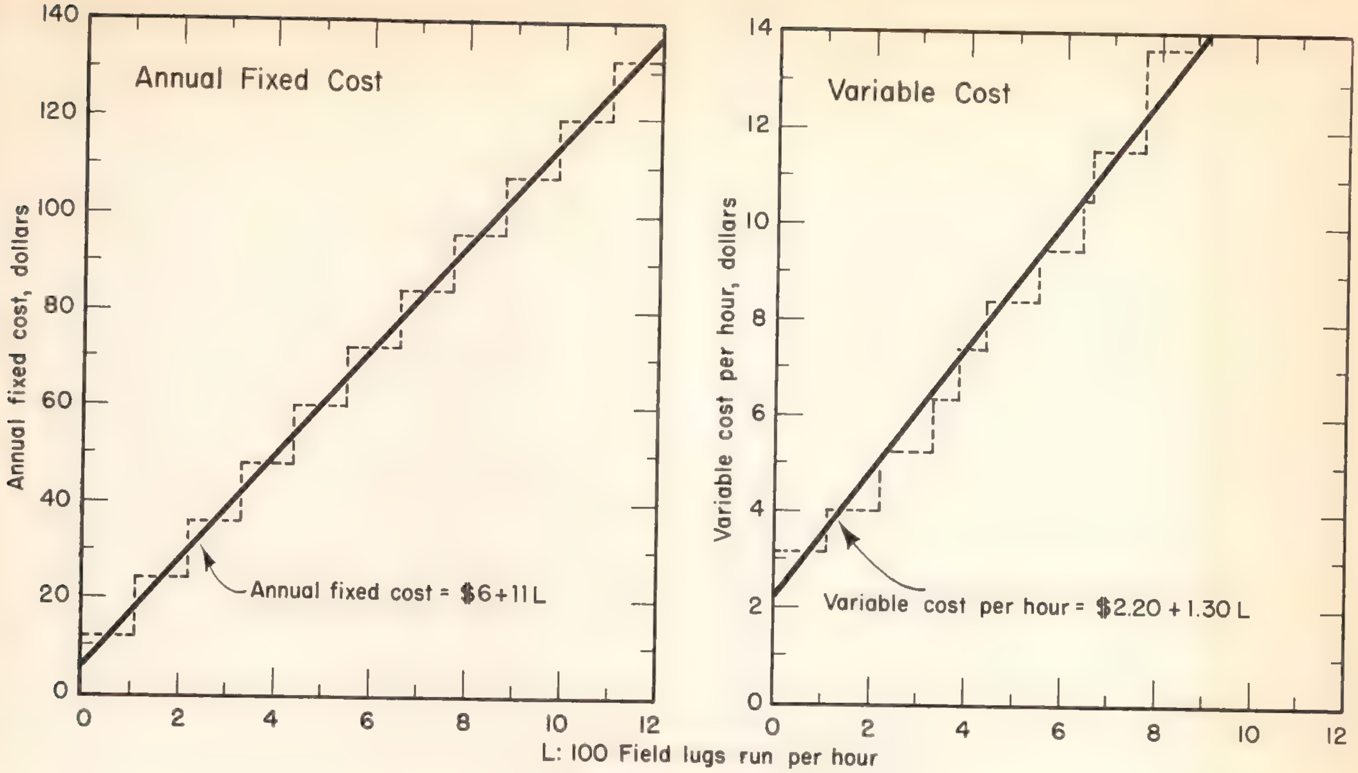
An alternative basis of comparison convenient in later developments in this report is illustrated in Figure 5. These charts show graphically the estimated variable and annual fixed costs with transportation method A that are given in Tables 3 and 4. As is evident in the tables, both variable and annual fixed costs increase on a step-by-step basis as plants of larger capacity are considered. The use of the data is greatly simplified, however, if the discontinuous cost-output relationship represented in Figure 5 is expressed on an average basis that "smooths out" the step-cost line in a manner illustrated by the solid, straight line appearing in each panel of the chart.1/ The cost relationships represented by such lines then may be expressed in terms of simple equations which describe in a general way the level of variable and annual fixed cost that may be expected with the use of particular transportation methods and equipment in plants of given capacity where performance rates of the order used in the above analyses can be attained. Thus with hand truck method A, the equations for variable and annual fixed costs are:

$$\text{Annual fixed cost} = \$6.00 + \$11.00\ (L)$$

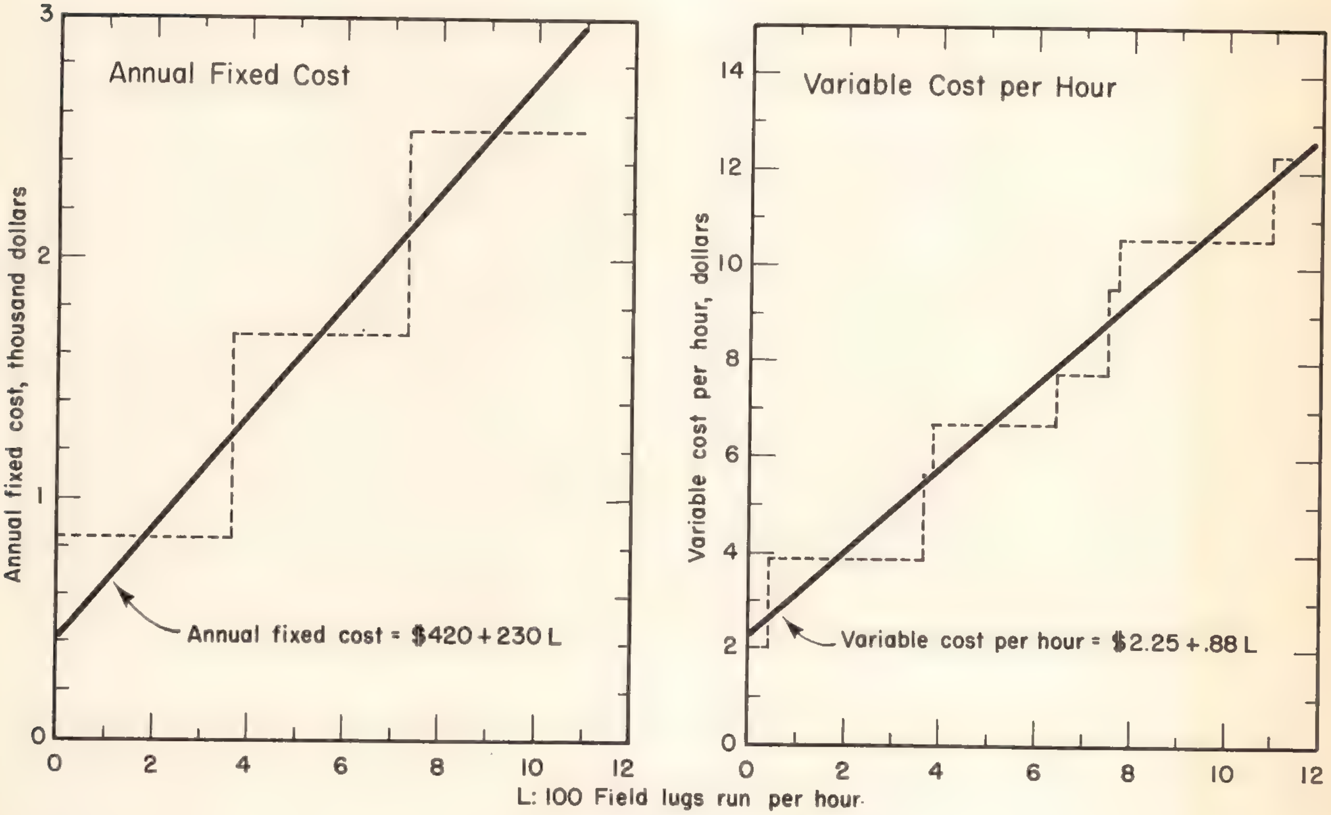
$$\text{Variable cost per hour} = \$2.20 + \$1.30\ (L)$$

where "L" represents 100 field lugs run per hour. These and equations similarly determined for other transportation methods are given in Tables 3 and 4.

1/ While the step cost relationship reflects correctly the manner in which crew and equipment are augmented as plant capacity is increased, the smoothed cost-line may be claimed to represent the "average" relationship if many different plants of any given size are considered. This may be attributed to normal variation in output rate to be expected from different workers and to the possibility of some integration of workers on different jobs.



A. HAND TRUCK PLANT



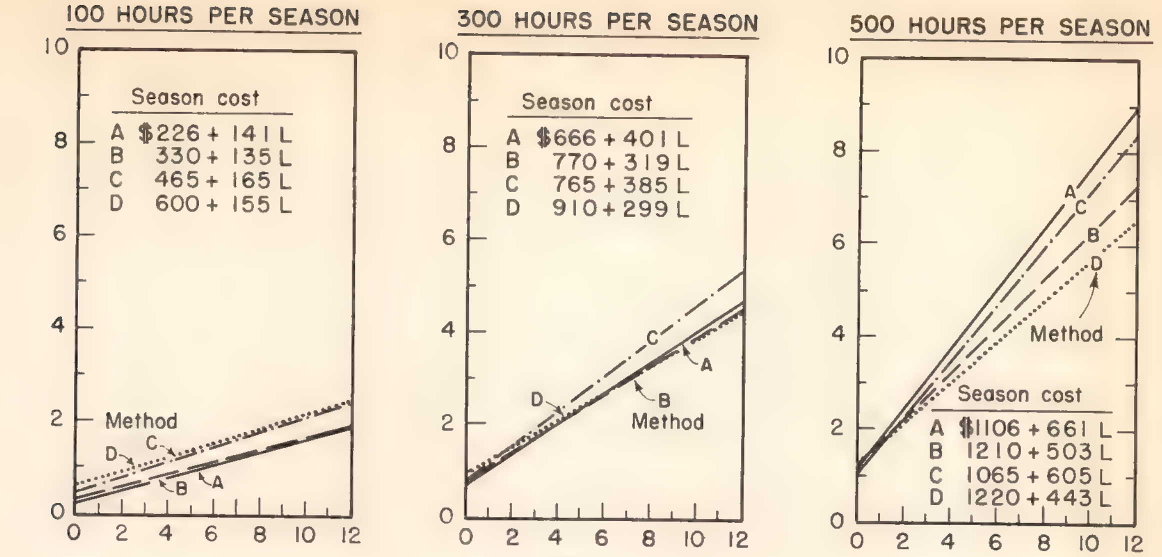
B. FORK TRUCK PLANT

Figure 5. Annual Fixed Costs And Variable Costs Per Hour In Hand Truck And Fork Truck Plants Using Transportation Method A In Packing California Fresh Plums, 1955.

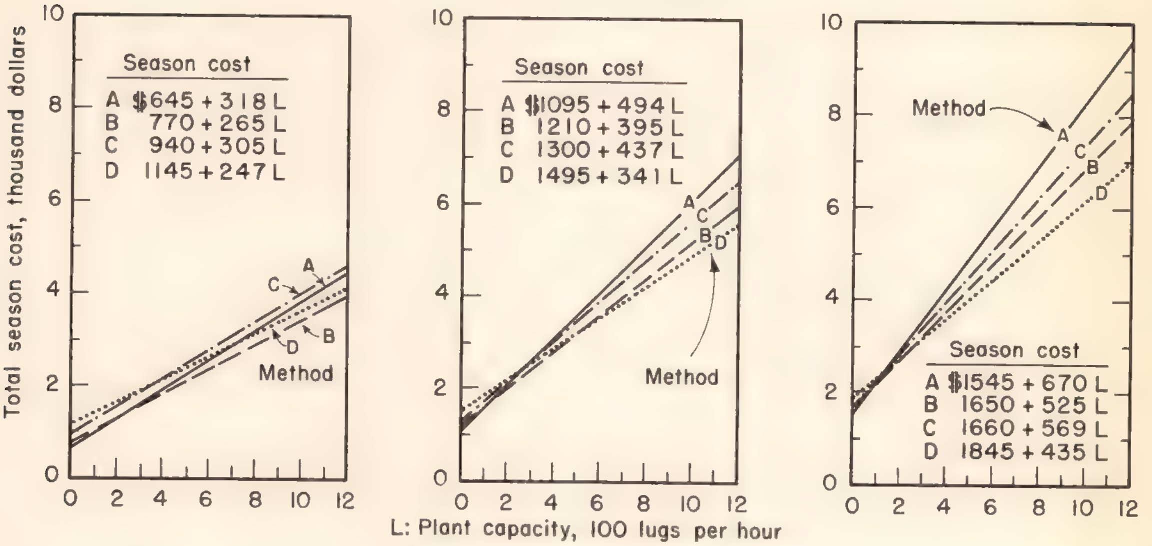
Equations such as the above may be used to compute total season cost in relation to both plant capacity and hours of operation per season. Using the above equations, for example, to estimate total season cost in a plant of 600 lugs per hour capacity and 300 hours' operation per season, 6.0 is substituted for "L" to obtain values of $72 for the annual fixed charge and $10 per hour for the variable cost. In a season of 300 hours' operation, total cost would then amount to $3,072. This is roughly the same value as that previously estimated directly from Table 3.

Total season cost computations made as in the above example in regard to all methods with hand- and fork-truck transportation equipment and with seasons of 100, 300, and 500 hours' operation are shown graphically in Figure 6. With both hand- and fork-truck equipment, the charts indicate mechanized methods to become more economical as rate of output and length of season increase. With hand-truck operation and 100 hours' operation per season, for example, method A is lowest in cost throughout the range in output rates considered. With a season of 300 hours' operation, however, method B, involving the use of conveyors in the transportation of packed fruit, gives lowest cost in plants with capacities of about 130 to 700 field lugs per hour. Method D, in which conveyors are used for both packed fruit and culls, is lowest in cost in plants of capacity exceeding about 700 field lugs per hour. With 500 hours' operation per season, method D is lowest in cost except with low rates of plant output. Similar effects are shown in the charts relating to fork-truck transportation.

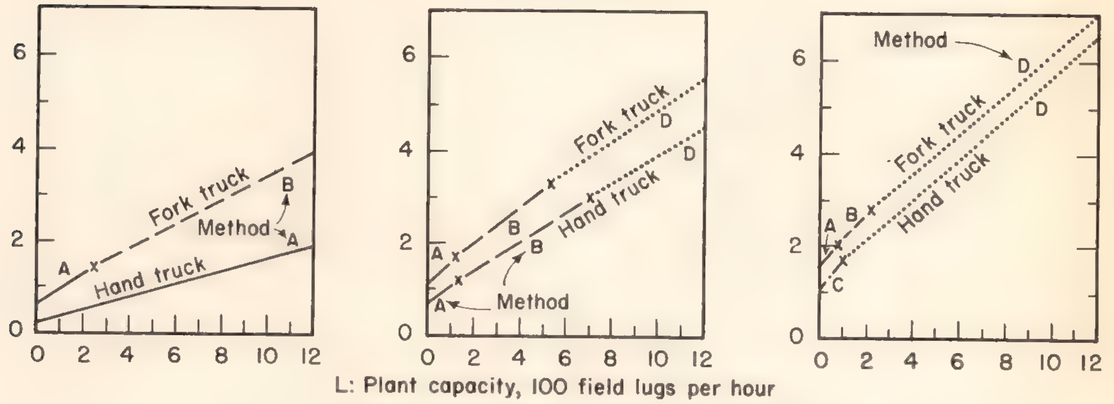
Comparison of total season costs with hand- and fork-truck equipment is made in the lower panel of Figure 6. Here the cost-line with each type of equipment consists of segments of cost-lines selected from the upper panels so as to represent in relation to plant size the least-cost method in hand- and fork-truck plants. Thus, with 100 hours' operation per season, hand-truck method A is shown to be the low-cost method throughout the range in plant capacities considered. In the fork-truck plants, method A is lowest in cost up to plant capacities of about 240 field lugs per hour, while method B is lowest in cost in plants of larger size. In both types of plant, the use of conveyor equipment in the transportation of packed fruit and culls--method B or D--is economical as length of season increases. Since total season costs are lower in hand- than in fork-truck plants throughout the range in output rates and lengths of season considered,



A. HAND TRUCK



B. FORK TRUCK



C. COMPARISONS, LOW COST METHODS

Figure 6. Total Season Cost Of In-Plant Transportation In Handtruck And Fork Truck Plants Using The Standard Crate As The Packed Fruit Container, Shown In Relation To Capacity Rate Of Plant Output, Length Of Operating Season And Transportation Method Used.

later developments in this report are based on the selection of hand-truck equipment for in-plant transportation.[1]

The above is based on the assumption that all fruit is packed in the standard crate. Transportation costs are slightly modified with some methods if the fiberboard container is used for packed fruit. The results of analysis similar to the above, but based on the use of cartons, are given in Appendix Table D.

Dumping Field Lugs of Fruit

Field lugs were dumped by hand in all the plum packing houses studied. Machine-dumping equipment is available, however, and so data concerning these methods obtained in other studies are used to evaluate the economy of their use in packing fresh plums.[2] Two methods in manual operation are considered. In one method the lugs are emptied and restacked by a single worker. In the other, conveyors supply full lugs to the dumper and take away the empty lugs; while additional workers are required to set full lugs on the conveyor and to remove and stack empty lugs.[3] The operations with machine dumping are similar to those with manual methods, except that a machine is used to empty the full lug.

Dumping Methods

Four methods of dumping are analyzed. A description of each method is given below.

Method A: Hand dumping. With this method, the dumper obtains the full lug from a stack on the floor, empties and restacks the lug.

---

[1] Different types of construction are commonly used with hand-truck and fork-truck transportation methods. Comparison of costs with the two types of structures indicates that building investment costs and annual fixed charges are slightly higher in the fork-truck plants. Consideration of building costs would not, therefore, modify the conclusions as to choice of equipment indicated here.

[2] See Sammet, Costs of Dumping Incoming Fruit as Related to Work Methods, Apple and Pear Packing (Berkeley: University of California, Division of Agricultural Sciences, Agricultural Experiment Station, June, 1953), 42p. (Giannini Foundation Mimeographed Report No. 153.)

[3] Workers transferring lugs to conveyors are called "seton" workers; those removing and stacking lugs are called "setoff" workers.

Method B: Hand dumping with conveyor aids. Full lugs are placed on a conveyor to the dumper by a seton worker. The dumper receives and empties the lug and places it on a conveyor leading to the empty-lug storage area, where it is set off and stacked by another worker.

Method C: Single-lug machine dumper. Operations with this method are similar to method B, except that the full lug is conveyor-fed to a dumping machine which automatically empties and returns the lug to the empty-lug conveyor. The dumping crew consists of seton and setoff workers for full and empty lugs. Machine attendance--for example to stop the machine in the event of jamming--is performed by the seton worker.

Method D: Stack dumper. The procedure with this method is the same as with method C--the single-lug dumper--except that the full lugs are fed into the dumping machine in single stacks. The machine automatically destacks the lugs one at a time, empties the contents, and places the empty lug on a conveyor. As the last stack is dumped, a new stack is moved into place by a floor chain conveyor. Stacks of lugs are brought to the machine by hand truck, and machine attendance is provided by this worker.

Crew and Equipment Requirements and Costs

Production standards for each manual method of dumping incoming fruit--based on time and production studies of plant operations--are given in Table 5 and Appendix Table B. Information from these studies and from equipment manufacturers was used to establish working capacity rates for machine dumping equipment. Manufacturers of the single-lug dumping machine estimated its capacity in the range of 720 to 1,000 lugs per hour, while the capacity of stack-dumping equipment was estimated to be in the range of 800 to 1,200 lugs per hour. For this analysis, the capacity rate is standardized at 750 lugs per hour. With the delay allowance of 20 per cent applied to this stage, the effective rate is 600 lugs per hour.

As in the estimation of costs in the transportation stage, the labor and machine standards are used to develop crew and equipment requirements in relation to plant output rate.[1] Unit prices for equipment and appropriate wage rates applied to estimates of labor required are used in estimating variable and investment costs and for computing an estimated annual fixed charge. Labor and

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[1] Three labor categories--dumper, seton, and setoff--are shown with the various methods in Table 5. A fourth job closely related to the dumping operations--trucking field lugs to and from the dumper or seton worker--is included in the in-plant transportation stage and not shown here.

TABLE 5

Labor and Equipment Requirements and Costs in Dumping Field Lugs as Affected by Capacity Rate and Method of Dumping. Packing California Plums, 1955

Method of dumping	Dumping stations	Crew capacity[a]	Job and crew size			Variable costs per hour			Fixed costs		Equations of annual fixed cost and variable cost per hour[f]
			Dumper	Set on	Set off	Labor[b]	Equipment repair and power[c]	Total	Equipment replacement cost[d]	Annual fixed cost[e]	
	number	lugs per hour	number of workers			dollars					
Method A Hand dumping	1	350	1	[g]		1.05	[h]	1.05	40	5	Annual fixed cost = 3 + 2L
	2	700	2			2.10	[h]	2.10	80	10	
	3	1,050	3			3.15	.01	3.16	120	15	
	4	1,400	4			4.20	.01	4.21	160	20	Variable cost per hour = .53 + .30L
Method B Hand dumping with conveyor aids	1	460	1	1	1	3.15	.08	3.23	1,185	155	Annual fixed cost = 80 + 34L
	2	585	2	2	1	5.25	.15	5.40	2,370	315	
	2	920	2	2	2	6.30	.15	6.45	2,370	315	
	3	1,170	3	3	2	8.40	.23	8.63	3,555	470	Variable cost per hour = 1.80 + .65L
	3	1,380	3	3	3	9.45	.23	9.68	3,555	470	
Method C Single lug dumping machine	1	460		1	1	2.10	.20	2.30	2,800	370	
	1	585		2	1	3.15	.20	3.35	2,800	370	Annual fixed cost = 185 + 62L
	1	600		2	2	4.20	.20	4.40	2,800	370	
	2	920		2	2	4.20	.40	4.60	5,600	740	
	2	1,170		3	2	5.25	.40	5.65	5,600	740	Variable cost per hour = 1.35 + .41L
	2	1,200		3	3	6.30	.40	6.70	5,600	740	
Method D Stack dumping machine	1	585			1	1.05	.27	1.32	4,180	550	Annual fixed cost = 275 + 92L
	1	600			2	2.10	.27	2.37	4,180	550	
	2	1,170			2	2.10	.54	2.64	8,360	1,100	
	2	1,200			3	3.15	.54	3.69	8,360	1,100	Variable cost per hour = .75 + .21L

[a] Capacity dumping rate assumes dumper alternates with trucker with Method A and set-on worker with Method B. Labor standards (field lugs per hour). Method A: Dumper--350. Method B: Dumper--460; set on--460; and set off--585.

[b] Based on a wage rate of $1.05 for all workers. This includes an allowance of approximately 5 per cent of worker's pay for employer's contributions to Social Security, Workmen's Compensation Insurance, and other worker benefits.

[c] Variable repair is estimated at 0.5 per cent of replacement cost per 100 hours of use and power at $0.03 per hour per motor horsepower.

[d] Based on the following equipment requirements per dumping station. Method A: One dumping platform--$40. Method B: One dumping platform--$40; 25-foot power set-on conveyor--$535; and empty lug conveyor consisting of 20-foot power conveyor--$490, and 30-foot gravity conveyor--$120. Method C: One dumping machine--$1,300; 35-foot power set-on conveyor--$630; and empty lug conveyor consisting of 40-foot power conveyor--$660, and 44-foot gravity conveyor--$175. Method D: One dumping machine--$2,590; 20-foot floor conveyor--$720; and empty lug conveyor consisting of 40-foot power conveyor--$660, and 44-foot gravity conveyor--$175.

[e] Estimated as a per cent of replacement cost. See Appendix Table C for details.

[f] L = plant capacity in 100 lugs per hour.

[g] Blanks indicate job not performed with this method.

[h] Less than $0.005.

equipment standards, price and wage data, as well as crew and equipment requirements and costs in relation to method used and plant output rate are given in Table 5.

Simple equations relating variable costs per hour and annual fixed charge to plant output rate are--as in the transportation stage--developed from the estimated costs at particular plant output rates, and these equations are summarized in Table 5. From these equations, total season cost in relation to plant output are computed. Results with three lengths of season--100, 300, and 500 hours--are shown graphically in Figure 7. With each length of season, the graphic representation of total cost is supplemented with a set of equations that express the relation of total season cost in a season of specified length to rate of plant output and method used.

For the operating ranges illustrated in Figure 7, method A--involving manual dumping of the field lugs--is lowest in total season cost. Of the remaining methods, the stack dumper--method D--becomes relatively more economical as length of season increases but not sufficiently so to surpass method A within the range in season lengths considered.[1]

Quality Grading

Quality grading--or sorting--involves the selection and removal of overripe, undersize, and otherwise undesirable fruit as required to meet the standards for marketable plums.[2]

Method of Grading

While several different types of equipment are available for use in grading deciduous fruits, only one method was observed in the plants studied. It involves transporting the fruit on a conveyor belt past a group of workers who sort the fruit into different quality grades.[3] Cull fruit is transferred to drop chutes

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[1] See Sammet, Costs of Dumping Incoming Fruit . . ., p. 33.

[2] In most of the plants studied, the grading standards used were those applicable to shipments under federal-state inspection.

[3] Other types of grading equipment are available or under development. Many of these have devices for rotating the fruit on the table to facilitate easy and complete inspection, but no equipment of this type was used in the plants studied.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

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4/ [illegible]

5/ [illegible]

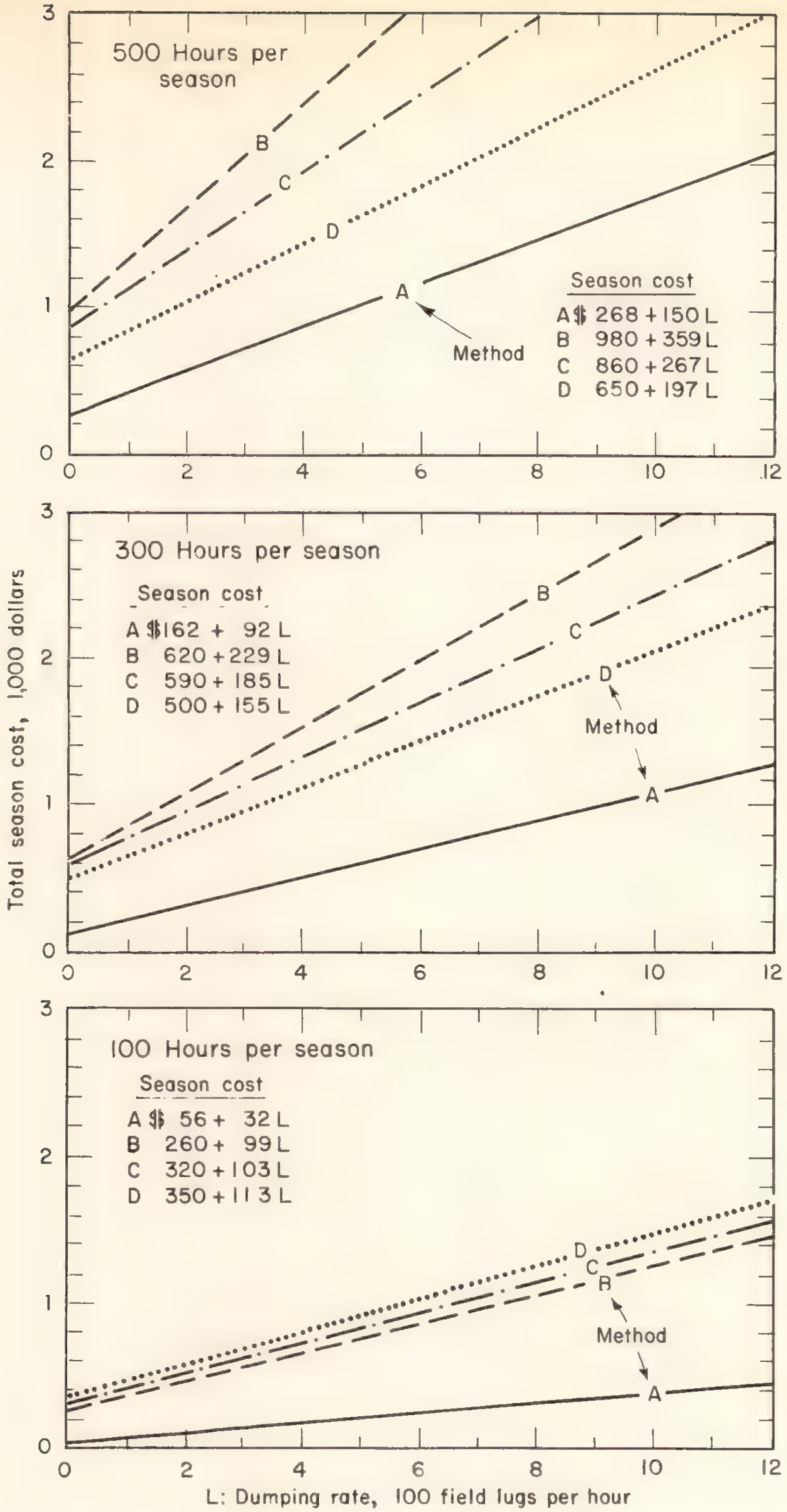

Figure 7. Total Season Costs of Four Methods of Dumping Field Lugs in Relation to Rate of Dumping and Length of Operating Season. Packing California Plums, 1955.

or placed directly on a center cull belt for transportation to a cull collection point. Fruit that is overripe for interstate shipment but otherwise sound is placed in lugs and later regraded and packed loose in containers for shipment to local markets. The main flow of fruit is conveyed beyond the grading table to the packing stations. In most plants, the fruit en route to the grading table passes over a presizer which mechanically removes most of the undersized fruit.

Labor and Equipment Requirements

A major part of the work performed by the grading crew consists merely of visual inspection with no easily measured input by the worker in relation to the volume of fruit graded. Therefore, conventional time-study methods of work measurement, which were used for other plant operations, are inappropriate for measuring sorter labor input.

Alternative means employed in the analysis of grading labor requirements involves the use of accounting records of labor utilization and output in a sample of plants. The aim in this analysis is to establish a work standard comparable to those obtained by means of time and production study--that is, a standard attainable by the average worker when idle time is held to a minimum level. Since observations in the plants indicated relatively infrequent adjustment in grading-crew size despite substantial changes in the proportion of culls and in total volume of fruit run, it appears reasonable to conclude that surplus labor was available at some times. To offset the reflection of this effect in the accounting data, the analysis is based on selected high-output days. The number of low-output days thus excluded comprise about one third of the total days sampled.

Graphical and statistical analysis of the remaining data was designed to show the effect of volume packed and volume of cull fruit on sorter labor requirements.[1] Volume packed was measured in terms of daily average quantity of fruit packed per hour, while culls were measured in terms of volume of fruit removed by the presizer and sorting crew per hour.[2] From this analysis, the

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[1] This method of analysis is described in more detail in Sammet, "Economic and Engineering Factors in Processing Plant Design" (Ph.D. thesis, University of California, January, 1958), p. 167.

[2] Isolation in the analysis of the effects of removal of fruit by the presizer as compared with the grading crew would have been desirable. None of the plants studied, however, maintained a separate accounting of cull volume attributable individually to the presizer and manual sorting crew.

following equation relating hours of grader labor required per grading table in relation to total volume run and the volume of culls per table was developed.

$$\text{Grader hours per table} = 1.28 + 0.36(P) + 0.62(C),$$

where "P" represents 1,000 pounds of fruit packed per hour, and "C" represents 1,000 pounds of culls and overripe fruit sorted out per hour. This equation indicates each 1,000-pound increase in fruit packed per hour to require approximately an additional one-third hour of sorter labor per hour, while a corresponding increase in the volume of fruit diverted to culls and overripes requires an increase of roughly two-thirds hours of sorter labor per hour.

The above equation is used to develop estimates of grader crew requirements in relation to capacity output rates. Table 6 shows for three levels of culling--culls and overripes constituting 10, 20, and 40 per cent of the total fruit run--the volume of plant output that can be handled by sorter crews of given size. The number of sorting tables required for a given plant capacity depends on the size of table used in a particular plant. Practical considerations as to layout and conveyor dimensions were followed in specifying size of grading table. Size specifications and the number of tables required for selected capacity output rates are given in Table 6.

Crew size and equipment required in relation to volume of output are, as in the preceding stage analyses, the basis for estimates of variable and annual fixed costs. Wage rates, unit installed prices for equipment, and other cost rates required in such computations as well as estimated variable costs per hour and fixed costs in relation to volume of output are given in Table 6. The table also expresses variable cost per hour and annual fixed charges in the form of simple equations which relate these costs to plant capacity in field lugs run per hour. These equations are then used to estimate total season cost. Results for seasons of 100, 300, and 500 hours' length are shown graphically in Figure 8. Each panel contains equations that--for the season length specified--relates total season cost to plant capacity.

Packaging

Labor and container materials costs in packaging fresh plums constitute the major portion of plum packing costs. A major objective of this study is the evaluation of costs with alternative types of containers and methods of filling them.

TABLE 6

Grading Labor and Equipment Requirements and Costs in Relation to Plant Capacity and Per Cent of Culls.
Packing California Plums, 1955

Plant capacity[a]	Grading tables	Graders[b]	Variable costs per hour			Fixed costs		Equations of annual fixed cost and variable cost per hour[g]
			Labor[c]	Equipment repair and power[d]	Total	Equipment replacement cost[e]	Annual fixed cost[f]	
field lugs per hour	number		dollars					
	10 per cent culls							
50	1	2	1.90	.16	2.06	2,615	355	Annual fixed cost = $170 + 83L$ Variable cost per hour = $1.75 + 1.46L$
125	1	3	2.85	.16	3.01	2,615	355	
195	1	4	3.80	.16	3.96	2,615	355	
270	1	5	4.75	.16	4.91	2,615	355	
340	1	6	5.70	.16	5.86	2,615	355	
410	1	7	6.65	.22	6.87	3,685	515	
485	1	8	7.60	.22	7.82	3,685	515	
555	1	9	8.55	.22	8.77	3,685	515	
625	1	10	9.50	.22	9.72	3,685	515	
675	2	12	11.40	.39	11.79	6,300	870	
750	2	13	12.35	.39	12.74	6,300	870	
820	2	14	13.30	.39	13.69	6,300	870	
895	2	15	14.25	.39	14.64	6,300	870	
965	2	16	15.20	.39	15.59	6,300	870	
1,035	2	17	16.15	.45	16.60	7,370	1,030	
1,110	2	18	17.10	.45	17.55	7,370	1,030	
1,180	2	19	18.05	.45	18.50	7,370	1,030	
1,250	2	20	19.00	.45	19.45	7,370	1,030	
	20 per cent culls							
50	1	2	1.90	.16	2.06	2,615	355	Annual fixed cost = $180 + 88L$ Variable cost per hour = $1.70 + 1.55L$
115	1	3	2.85	.16	3.01	2,615	355	
185	1	4	3.80	.16	3.96	2,615	355	
250	1	5	4.75	.16	4.91	2,615	355	
320	1	6	5.70	.16	5.86	2,615	355	
385	1	7	6.65	.22	6.87	3,685	515	
450	1	8	7.60	.22	7.82	3,685	515	
520	1	9	8.55	.22	8.77	3,685	515	
585	1	10	9.50	.22	9.72	3,685	515	
635	2	12	11.40	.39	11.79	6,300	870	
700	2	13	12.35	.39	12.74	6,300	870	
770	2	14	13.30	.39	13.69	6,300	870	
835	2	15	14.25	.39	14.64	6,300	870	
905	2	16	15.20	.39	15.59	6,300	870	
975	2	17	16.15	.45	16.60	7,370	1,030	
1,040	2	18	17.10	.45	17.55	7,370	1,030	
1,105	2	19	18.05	.45	18.50	7,370	1,030	
1,175	2	20	19.00	.45	19.45	7,370	1,030	
	40 per cent culls							
45	1	2	1.90	.16	2.06	2,615	355	Annual fixed cost = $195 + 97L$ Variable cost per hour = $1.70 + 1.74L$
105	1	3	2.85	.16	3.01	2,615	355	
165	1	4	3.80	.16	3.96	2,615	355	
225	1	5	4.75	.16	4.91	2,615	355	
285	1	6	5.70	.16	5.86	2,615	355	
345	1	7	6.65	.22	6.87	3,685	515	
405	1	8	7.60	.22	7.82	3,685	515	
465	1	9	8.55	.22	8.77	3,685	515	
525	1	10	9.50	.22	9.72	3,685	515	
565	2	12	11.40	.39	11.79	6,300	870	
625	2	13	12.35	.39	12.74	6,300	870	
685	2	14	13.30	.39	13.69	6,300	870	
745	2	15	14.25	.39	14.64	6,300	870	
805	2	16	15.20	.39	15.59	6,300	870	
865	2	17	16.15	.45	16.60	7,370	1,030	
925	2	18	17.10	.45	17.55	7,370	1,030	
985	2	19	18.05	.45	18.50	7,370	1,030	
1,045	2	20	19.00	.45	19.45	7,370	1,030	

a/ Based on a field lug net weight of 36 pounds or 27.8 field lugs per 1,000 pounds of total fruit run.

b/ The grading labor required is estimated by the following equation: Grader hours per grading table = $1.28 + 0.36P + .62C$; where P = 1,000 pounds fruit packed per hour and C = 1,000 pounds of culls and overripes packed per hour.

c/ Based on a wage rate of $0.95 per hour which includes an allowance of approximately 5 per cent of worker's pay for employer's contributions to Social Security, Workmen's Compensation Insurance and other worker benefits.

d/ Equipment variable repair estimated at 0.5 per cent of replacement cost per 100 hours use and electric power at $0.03 per hour per motor horsepower.

e/ Based on the use of a 10 1/2-foot grading table for 6 graders or less and one 17 1/2-foot table for 7 to 10 graders. For 12 to 16 graders, one 10 1/2-foot and one 17 1/2-foot table is used; for 16 to 20 graders, two 17 1/2-foot tables are used. With the larger table, a belt is required to distribute fruit to more than one packing line. Presizer is required for each grading table. Replacement costs: presizer--$2,000; 10 1/2-foot grading table--$615; 17 1/2-foot grading table--$825; and 30-foot distribution belt--$860.

f/ Estimated as a percentage of replacement cost of 13.2 per cent for the presizer and 14.8 per cent for the grading table and distribution belt. See Appendix Table C.

g/ L = plant capacity in 100 field lugs per hour.

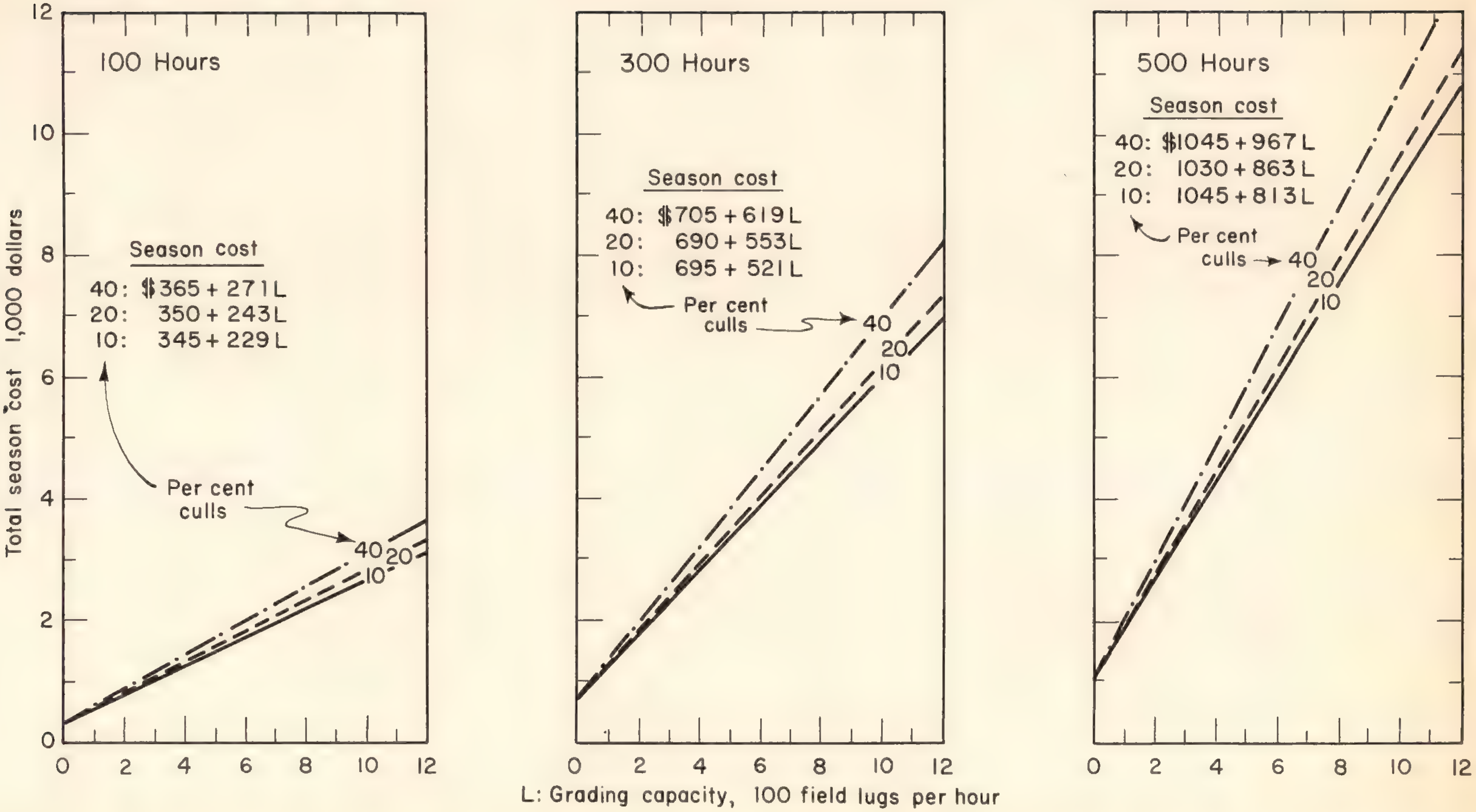

Figure 8. Total Season Cost of Grading Plums in Relation to Grading Capacity Rate, Per Cent Culls, and Length of Season. Packing California Plums, 1955.

Packaging Methods

Two broad categories of plum packaging methods are considered. One category includes methods in which all or a portion of the plums are "place-packed" manually in a definite pattern. The other includes methods in which the packages are bulk filled to a predetermined weight, with the filling operation performed either manually from bulk bins or by automatic machinery. Presently, most California plums are place-packed in a standard wooden crate which contains four split-wood baskets and approximately 28 pounds net weight of fruit. A small volume of large-size fruit is individually wrapped, place-packed, and shipped interstate in "peach lugs" holding approximately 18 pounds of plums. A few plants ship plums in the "Brentwood lug" containing approximately 25 pounds net weight and used primarily for small fruit--mainly the Tragedy variety. The Brentwood lug is partially place-packed with the remainder bulk filled. Trial shipments also have been made using a fiberboard container suitable either for place-pack or bulk-fill methods.[1] Some of these container types--used primarily in interstate shipments--are illustrated in Figure 9. In addition, a relatively small volume of fruit is bulk filled in Los Angeles lugs to a net weight of about 30 pounds for shipment to California markets.

Several different packaging methods and types of equipment may be used in the container-filling operations. The following methods are given specific consideration.

Method A: Crate, belt pack. With this method, quality graded but unsized fruit is carried by conveyor belt along a line of packers who select fruit of given size and transfer it to the container. The plums are placed firmly in layers in each of four split-wood baskets contained in the crate. The placement pattern depends on the size of fruit packed.[2] An outgoing belt conveys the fruit away from the grading table, while a return belt returns unpacked fruit for regarding or recirculation to the packers. Packers generally work at both the outgoing and return belt, with about 3½ feet of conveyor length assigned per packer. (Figure 10-A.)

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[1] Test shipments were designed and conducted by the California Grape and Tree Fruit League and an industry advisory committee in cooperation with the U. S. Department of Agriculture. For details, see Pilz, Edmund J., Goodloe Barry and Donald R. Stokes, New Shipping Containers for Plums (Washington: Govt. Print. Off., June, 1956), 44p. (U. S. Department of Agriculture, Marketing Research Service Report No. 128.)

[2] Designation of fruit size for the standard crate is based on a row count of the top layer of fruit in each wooden basket. For example, in a crate of 4 x 4 size fruit, the top layer in each basket contains four rows of four plums each.

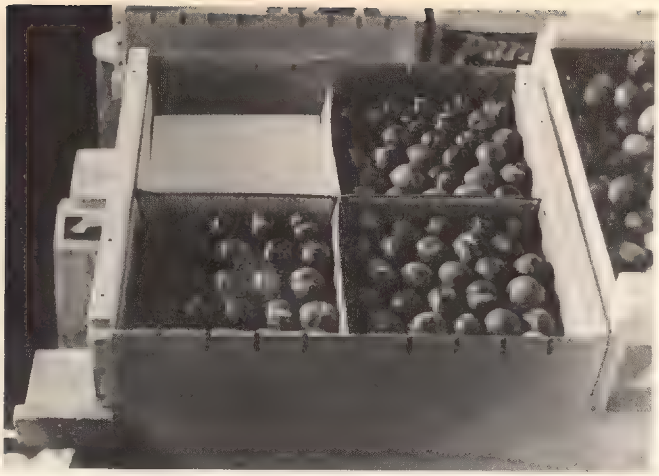
Two broad categories of plum packaging methods are considered. One category includes methods in which all or a portion of the plums are "place-packed" manually in a definite pattern. The other includes methods in which the packages are bulk filled to a predetermined weight, with the filling operation performed either manually from bulk bins or by automatic machinery. Presently, most California plums are place-packed in a standard wooden crate which consists of four split-end baskets and approximately 28 pounds net weight of fruit. A small volume of large-size fruit is individually wrapped, place-packed, and shipped interstate in "peach lugs" holding approximately 22 pounds of plums. A few shippers [illegible] plums in the "Stevenson lug" containing approximately 25 pounds net weight, and used primarily for small fruit--mainly the [illegible] variety. The Stevenson lug is partially place-packed with the remainder bulk filled. Trial shipments also have been made using a fiberboard container suitable either for place-packing or bulk-fill methods.1/ Some of these container types--used primarily in interstate shipments--are illustrated in figure 2. In addition, a relatively small volume of fruit is bulk filled in lugs or [illegible] crates for shipment to California markets.

Several different packaging methods and types of equipment are used in the container filling operations. The following methods are given specific designations:

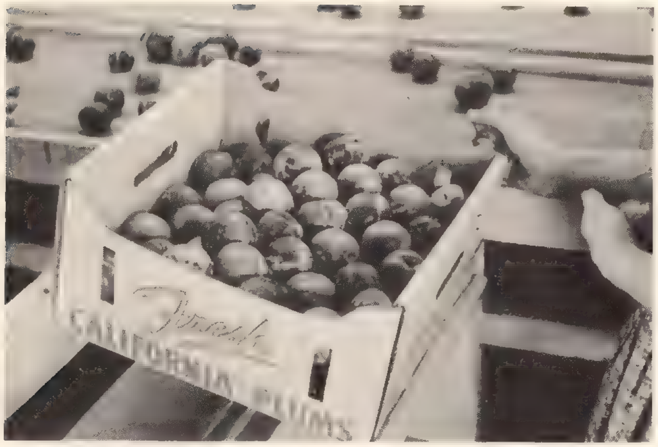
Method A: Grade, fill pack. With this method, quality graded fruit moves [illegible] from the [illegible] by conveyor belt along [illegible]. The packers select fruit of given size and transfer it to the [illegible]. The plums are placed firmly in layers in each of four split-wood baskets contained in the crate. The placement pattern depends on the size of fruit packed.2/ An outgoing belt conveys the fruit away from the grading table while a return belt returns unused fruit for regrading or redistribution to the packers. Packers generally work at both the outgoing and return belt, each [illegible]

1/ Test shipments were designed and conducted by the California Tree Fruit League and an industry advisory committee in cooperation with the U. S. Department of Agriculture. For details, see [illegible], Donald [illegible], New Shipping Containers for Plums (Washington: Govt. Print. Off., [illegible]), [illegible] pp. (U. S. Department of Agriculture, Marketing Research Service Report No. [illegible])

2/ Designation of fruit size for the standard crate is based on a count of the top layer of fruit in each wooden basket. For example, in a crate of 4 x 5 size fruit, the top layer in each basket contains 4 rows of five plums each.

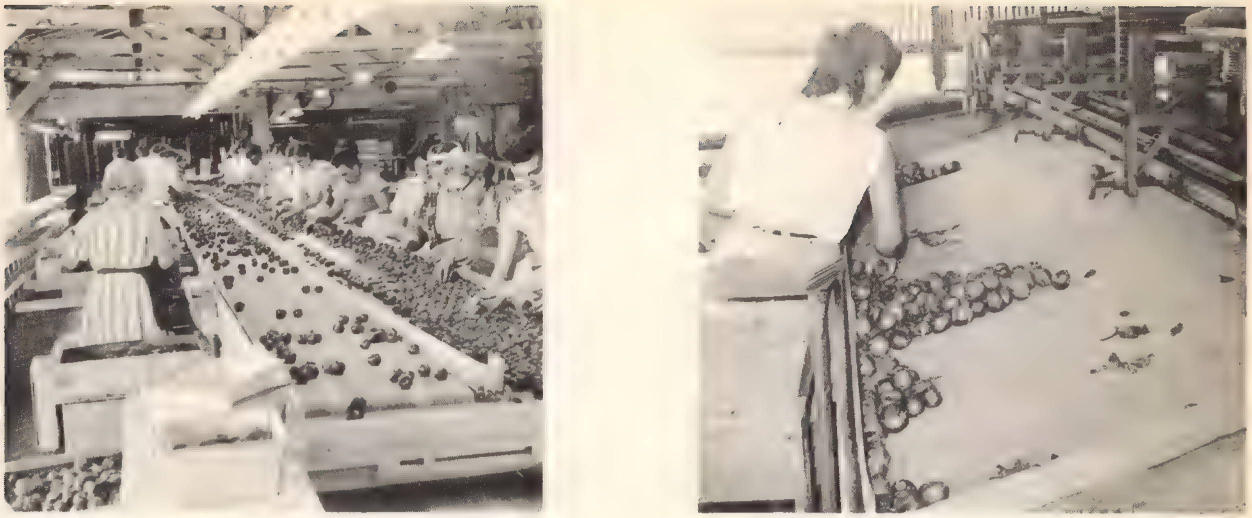


A. Partially packed crate of 5 x 6 size fruit showing the internal package components



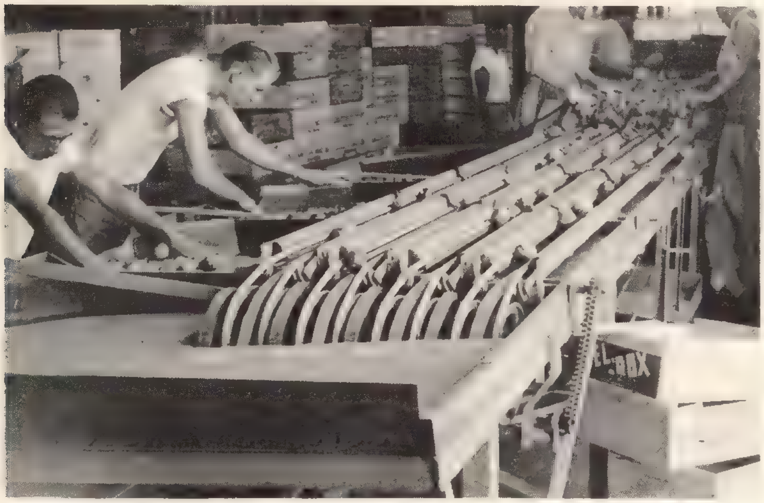
B. Partially packed telescope carton

Figure 9. The Standard Crate and One of the Test Cartons Used for Interstate Shipments of Plums



A. Belt equipment

B. Bin equipment with rope sizing unit



C. Rope sizer and padded bins for bulk-filling containers

Figure 10. Principal Types of Equipment for Packaging Plums

Method B: Carton, belt pack. The packing equipment and methods are the same as with method A, except that the fruit is place-packed in a carton. A definite pattern of placement in layers is used, depending upon the size of plums packed, but the pack is looser and less care in placement is required than with the standard crate.

Method C: Crate, bin pack. With this method, graded fruit passes over a rope sizer which separates the plums into gradations of size along the padded packing bins. The packing procedure is similar to method A, except that the job of selecting the correct fruit size has been reduced. (Figure 10-B.)

Method D: Carton, bin pack. Procedure and equipment with this method are similar to method C, except that the fruit is packed in cartons rather than crates.

Method E: Rope sizing, bulk fill. Fruit is quality graded, then separated by means of rope sizers into 3 sizes that are packaged for shipment plus an undersize, with fruit in each size category delivered to separate bins. The bins incline toward a filling station, where fruit is pulled manually from bin to container. The container is leveled and transferred to a packed fruit conveyor by a station attendant. Either wood or fiberboard containers may be used. (Figure 10-C.)

Method F: Drop-roll sizing, bulk fill. Method E is duplicated, except for the substitution of drop-roll equipment for the rope sizer. The fruit enters the sizer on closely spaced metal rolls. As the fruit is carried through the sizer, the roll-spacing increases allowing the fruit to drop in predetermined size categories to belts that convey the fruit to packing bins.[1]

Method G: Automatic, bulk fill. This completely automatic bulk-filling method is presently used primarily in packaging citrus fruits. With minor modifications, however, it should be adaptable for use in filling plum containers. It involves use of a drop-roll sizer linked by a conveyor system to automatic filling stations. The container is automatically filled to a predetermined weight and ejected onto a packed fruit conveyor while an empty container moves into position for filling.

Labor Standards

In the estimation of costs with the various packaging methods, production standards are developed for place packing in different types of containers and with different types of equipment as well as for bulk-filling operations. Numerous factors affecting rates of output on these jobs are considered, especially in regard to place-pack methods. Place-packing time per container may be

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[1] It is not known whether there are differences in the quality of sizing done by the rope and drop-roll sizing equipment.

expected, for example, to increase as fruit of smaller size is packed, while smaller unit times may be expected if incentive piece-rate wages are paid as compared with hourly-rate wages. Type of equipment used--that is, whether bin or belt--may affect packing time and so may variety of fruit packed. Special consideration also is necessary in estimating time requirements in packing the test carton to take account of lack of familiarity of individual packers with this type of container.

Place-Packing Standards.--Place packing plums in either type of container requires the performance of miscellaneous operations such as obtaining and stamping the empty container, and placing pads and liners. These operations, however, require a relatively small proportion of the total time per container and are not greatly affected by type of container and type of equipment used. Most of the place-packing labor is expended in the selection and placing of individual plums. Time-study methods were used to establish unit times for each miscellaneous operation and to estimate unit time per 100 fruits selected and placed in the container. Relatively detailed analysis of the latter operation was required. This involved separate determination of unit times with belt- and bin-type equipment and--with each type of equipment--estimates for crate and carton packing. In regard to all measurements except the select-and-place fruit element with the carton, the time standards represent simple averages of net unit times per container for a large sample of workers. In regard to the test carton, however, the time-study measurements were obtained in such a way as to permit projecting the rate of improvement in packing rate with increased packing experience. The time standards used are based on projections of estimated unit time to a total experience level with the new container of 200 cartons per packer. This quantity was considered sufficient to reflect the performance rates of experienced packers, especially in view of the high degree of similarity with operations performed in packing the standard crate and the nature of the new-job content. The unit times determined for these operations are based on the payment of piece-rate incentive wages to place-pack workers, the common practice in this industry.

Time standards for the place-packing operations are given in Table 7. On belt-type equipment, miscellaneous operations are shown in the table to require a total of 0.92 man-minutes per crate and--due to the need for handling fewer components--only 0.65 man-minutes per carton. The select-and-place fruit element is shown to require less time with either type of container when bin-type equipment is used as compared with belts; and time requirements per 100 fruits placed were less--with a given type of equipment--with cartons than with crates. The unit times are not differentiated as to variety as the principal effect of this

TABLE 7

Labor Requirements and Standards for Place-Packing Plums in the Standard Crate and Test Carton from Bin and Belt Equipment. California, 1955

A. Productive Time

Item	Belt equipment		Bin equipment	
	Method A--standard crate	Method B--test carton	Method C--standard crate	Method D--test carton
	minutes			
Miscellaneous elements				
Get container and mark	.19	.19	.16	.16
Place 4 baskets	.15	[a]	.12	
Place 8 shims	.23		.20	
Place 4 collars	.23		.16	
Place 1 bottom pad		.14		.13
Place top tray		.20		.17
Transfer container to conveyor	.12	.12	.10	.10
Select and place 100 fruit	3.20	2.83	2.33	1.91

B. Labor standards[b]

Size	Plums per package[c]	Belt equipment		Bin equipment	
		Method A--standard crate	Method B--test carton	Method C--standard crate	Method D--test carton
	number	packages per hour			
Crate					
3 x 4	128	10.40		14.35	
4 x 4	176	7.95		11.05	
3 x 4 x 5	204	7.00		9.75	
4 x 5	224	6.45		8.95	
5 x 5	280	5.30		7.35	
5 x 6	340	4.40		6.15	
6 x 6	408	3.75		5.20	
Carton					
5 rows	101		14.90		21.50
5½ rows	114		13.45		19.50
6 rows	137		11.50		16.80
6½ rows	170		9.55		14.00
7 rows	214		7.80		11.50
7½ rows	236		7.10		10.55
8 rows	271		6.30		9.30
8½ rows	318		5.40		8.05

[a] Blanks indicate this operation not performed with this type container.

[b] Labor standards are determined by first multiplying the time to "select and place 100 fruit" by the hundreds of fruit per container and adding this to the sum of the times for the miscellaneous productive elements to give total productive time per package. An allowance for rest periods, personal time, and unavoidable delay of 14.9 per cent of total productive time with belt equipment and 12.2 per cent with bin equipment is then added to give the total time per package.

[c] The number of plums of a given size packed in the carton varied slightly among plants. The typical number packed is indicated in this column.

factor was shown by the studies to be accounted for in terms of fruit size and the number of fruits required to fill a given container.

The time standards given in terms of net (or "productive") unit times in the upper portion of Table 7 are the basis for the estimated production standards given in the lower portion of this table. The standards indicate potential output per packer hour in relation to type of container and equipment and fruit size. They are determined by finding first the typical number of fruits per container in each size category, applying to this quantity the unit time to select and place fruit given in the upper portion of Table 7, then adding to this result the time required by miscellaneous elements. This total net unit time is then increased to allow for unavoidable delay and scheduled rest periods to arrive at a gross time per container. Gross time per container divided into 60 gives the production standards in containers per hour shown in the table.

Bulk-Fill Labor Standards.--Time studies of bulk-filling fruit from bin-type equipment were made in two plants using packing method E. Net labor requirements for placing and removing containers at the filling station, assisting the fill, and operating the bin door were determined as 0.626 man-minutes per container. An allowance of 25 per cent of net time to cover unavoidable delay was indicated by the studies to be essential, which makes the gross time required 0.783 man-minutes per container. The resulting production standard is approximately 75 packages per worker hour. This standard is presumed to apply to any of the different packages used in bulk-fill operations and to be appropriate with either the rope- or drop-roll sizing equipment used with packaging methods E and F.

Standards for Analysis.--From Table 7 it is clear that differences in fruit size have an important effect on place-packing labor requirements and may be an important variable in the estimation of packaging costs. To simplify the analysis, however, the following cost comparisons among different methods and containers are based on a single fruit size--the average size packed in the plants studied.[1] This approximates 200 fruits per crate and so the comparisons are based on the fruit size corresponding to the 3 x 4 x 5 size as packed in the standard crate, in which these are typically 204 plums and approximately 28

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[1] The effect of this simplification on relative costs with different methods depends largely on the packer wage plan used. If piece rates undifferentiated as to fruit size are used, the effects on relative costs are small. If piece rates are adjusted for differences in fruit size, or if the packers are paid an hourly wage, relative costs among methods may change substantially as fruit size is varied. This effect would be of little importance in comparisons of different methods of place-packing. Under some circumstances, however, it would significantly affect cost comparisons among place-pack and bulk-fill methods and in particular would encourage the use of bulk-fill methods with small-size fruit.

pounds net weight packed per crate. If the same average size fruit were packed in the carton, fruits per carton would average about 182 and net weight approximately 25 pounds per carton. On this basis, unit times for packing the carton must be adjusted by the factor 28/25 (an increase of 12 per cent) to place these estimates on the basis of weight-equivalence with the standard crate. Estimated time requirements and production standards per crate, carton, and crate equivalent in the carton are given in Table 8. Values also are given for packing the Brentwood lug and bulk-filling containers.

The table indicates an average time of 8.56 minutes per crate packed from belt equipment as compared with 7.47 minutes per crate equivalent of cartons packed from belts. With bin-type equipment the comparable unit times are 6.16 minutes per crate and 5.07 minutes per carton. These results indicate moderate time reduction in the use of the cartons as compared with crates and a substantial reduction in unit time requirements with bin as compared with belt equipment.[1] The use of bulk-fill methods, of course, is shown to be most economical of labor, reducing labor use to only 10 to 15 per cent of that required with the other packing methods.

Labor Costs

In place-packing plums, the packers commonly are paid on a piece-work basis. Most firms pay a flat rate per container regardless of fruit size, although in two of the plants studied, the rate was graduated so as to maintain packer earnings at a more nearly uniform level as fruit size varies. The piece rates observed in the San Joaquin Valley ranged from 11 to 17 cents per crate, with 12 cents the most common rate. In the Sacramento and Sierra Foothills districts, the rates ranged from 13 to 17 cents per crate with 14 cents the most common rate. A minimum payment of 75 cents per hour was required to conform with minimum

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[1] The unit packing times given for belt as compared with bin-type equipment reflect differences actually observed and believed to be typical of this equipment as actually used. In most plants using belts, however, there was strong evidence of overly intensive use of the packing equipment--that is, too many packers were employed in relation to the volume of fruit flow. As a result, productivity of packers at the end of the conveyor line frequently was low due to inadequate supplies of fruit or of particular fruit sizes. This tendency was much less evident in plants using bin-type equipment. It was not possible, however, to determine the impact of these circumstances on estimated unit packing times with the two types of equipment.

TABLE 8

Packaging Labor Standards Used in the Cost Synthesis of the Packaging Stage. California Plums, 1955

Method of packaging and type of equipment	Time and production standards	
	minutes per package	packages per worker hour
Belt equipment		
Standard crate (3 x 4 x 5)	8.56	7.00
Test carton (25 pounds net)	6.67	9.00
Test carton (crate equivalent)	7.47	8.05
Brentwood lug (crate equivalent)	4.76	12.60
Bin equipment		
Standard crate (3 x 4 x 5)	6.16	9.75
Test carton (25 pounds net)	4.53	13.25
Test carton (crate equivalent)	5.07	11.85
Bulk fill (crate equivalent)	.78	75.00[a]

[a] Rounded to the nearest five packages

wage standards,[1] but hourly earnings of experienced packers paid on a piece-rate basis easily exceed this level. Since the plant cost analysis is presented on the basis of average-size fruit, the piece rate most frequently observed-- 12 cents per standard crate--was selected.

While piece rates for place-packing the crate are relatively well established in each locality, there initially was insufficient experience with carton packing to provide a basis for fixing a suitable piece rate. Most firms paid for packing the test shipments on an hourly-rate basis, although some shifted to a piece-rate wage after sufficient packer experience had been accumulated to indicate an appropriate level. In the absence of an established rate for carton packing and for purposes of comparison it was assumed that hourly earnings in packing the carton would eventually stabilize at a level comparable with current earnings in packing the crate. Taking account of differences in packer output rates with crates and cartons, the rate of 12 cents per standard crate would correspond to 9.3 cents for the average 25-pound carton packed with belt-type equipment and 8.8 cents per carton if packed with bin-type equipment. If these rates are adjusted to a weight-equivalent basis, the corresponding piece-rate wages for cartons would be, respectively, 10.4 and 9.9 cents per crate equivalent.

With the bin-type equipment, supplementary labor frequently is employed to assist the packers. This work consists of pulling fruit down to the lower portions of the bins to make it more accessible to the packers and pushing packed fruit along the gravity conveyors leading to the lidder. These workers--called "bin boys"--were typically paid $1.00 per hour.

In the bulk-filling operations, the only labor involved is that of attendant at the container-filling station. These workers typically were paid $1.00 per hour.

When the employers' expenses for workmen's compensation and social security--approximately 5 per cent of direct wage payments--are added to the above, wage rates in the packaging stage are as follows: place-pack the standard crate, 12.6 cents per crate; place-pack a crate equivalent in cartons, 11.0 cents for cartons packed from belts and 10.4 cents for cartons packed from bins; and $1.05 per hour for bin boys and bulk-fill attendants.

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[1] In 1956, the minimum wage was raised to $1.00 per hour.

Equipment Requirements and Costs

A final component of costs in the packaging stage is the fixed charge for equipment and the building space occupied by it.[1] This varies with type of equipment and size of plant. A general description of the equipment used with each method has already been given. More detailed specifications, estimates of capacity output rate, and installed cost per equipment unit are given in Table 9. The equipment specified with each method includes packaging equipment--such as conveyors and bins--sizing equipment where required, and conveyors for transporting packed fruit to the lidder.

Packaging Costs

The production standards and cost data developed above are applied in Table 10 in the estimation of labor and equipment requirements and costs with each of the place-pack methods considered. The table gives, for selected output rates, the number of packaging lines required with each method and the number of workers required in each labor category. The number of hourly-rate workers and their typical wage rate are used to estimate labor costs in this category, while packer-labor costs are computed by applying the piece-rate wage to the number of containers packed. Equipment investment costs are based on quantities required in relation to output rate as indicated in Table 10 and unit equipment prices given in Table 9. The estimates of building investment given in Table 10 for space occupied by the packaging equipment are based on estimated space requirements and unit building costs developed in a later section.[2] Estimates of variable repair expense and of annual charge for equipment as well as equations relating annual charge and variable cost to plant size are given in Table 10. They are obtained by computations like those in previous stages.

Results obtained by a similar procedure are given in Table 11 for the bulk-fill packaging methods.

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[1] High-capacity methods, such as bulk-fill, require considerably less floor space than the place-pack methods. Building space requirements thus affect relative costs among different packaging methods, and so costs of the space used in packaging is included in this stage.

[2] As is evident in the building cost estimating data given later in Table 20, unit building investment costs decrease as size of building increases. This effect is reflected in the building investment costs given in Tables 10 and 11.

TABLE 9

Description of Packing Equipment and Estimated Replacement Costs for Each Method.
Packaging California Plums, 1955

Type of equipment	Packing method	Capacity per packing unit	Equipment replacement costs: Packaging unit	Packed fruit conveyor: First unit	Packed fruit conveyor: Each additional unit	Total cost of first unit
		crate equivalents	dollars			
Belts--Each unit composed of a packing belt 2 feet wide and of length up to 75 feet with a return belt 1½ feet wide. For 75-foot length with space for 40 packers. Power conveyor for packed fruit.	A and B	280[a]	4,900[b]	2,245[c]	1,210[c]	7,145
Bins--Each unit composed of a double line of bins placed back to back. Each double bin is 40 feet long and has a double line of rope sizers. Space adequate for 12 packers per unit. Gravity conveyor for packed fruit.	C and D	117[a]	1,480[d]	400[e]	240[e]	1,880
Bin bulk-fill with rope sizers--Each unit has a series of rope sizers which drop fruit of different sizes into compartments of the padded bin. Each unit is 36 feet long with room for 5 workers to fill container. Each filling station is equipped with a scale to weigh the container. Power conveyor for filled containers.	E	375	1,660[f]	700[g]	700[g]	2,360
Bulk-fill with drop roll sizer--Each unit has a belt conveyor and shears to transport and divert fruit of different sizes into compartments of the padded bin. The unit provides 10 filling stations each equipped with a scale to weigh the containers.	F	750	10,960[h]	1,055[i]	1,055[i]	12,015
Automatic filling equipment--Each unit has a drop roll or diverging roll sizer with belts and shears to transport fruit of different sizes to the filling stations. Each unit has six carton conveyors and automatic fillers and shakers.	G	750[j]	27,445[k]	[l]	[l]	27,445

a/ Packing capacity for packages other than the crate depends on the labor standard for that package (see Table 8).

b/ Investment cost of packing belt unit is estimated by the equation: Cost = \$550 + 50L, where L = length of belt unit in feet. Length of belt is estimated by the equation: L = 5 + 1.75W, where W = number of packers and L = belt length in feet. Also includes the cost of 40 packing stands at \$15 each.

c/ Investment cost of power conveyor for packed fruit is estimated by the equation: Cost = \$650 + \$9.50L for conveyor for the first packing line and Cost = \$325 + \$9.50L for conveyor for each additional packing line, where L = length of conveyor in feet. The length of conveyor required is estimated by the equation: L = 28 + 3.5W for the first packing line and L = 23 + 1.75W for each additional line, where W = number of packers per line and L = conveyor length in feet. With 40 packers per line, 168 feet of conveyor is required for the first packing line and 93 feet for each additional line. The cost of a mechanical interlock to regulate the flow of packages at the junction of two conveyors also is included.

d/ Includes the cost of 12 packing stands at \$15 each.

e/ Sidewheel gravity conveyor cost is estimated at \$4 per foot.

f/ Includes the cost of bin and rope sizers at \$160 per unit plus the cost of 5 scales at \$140 each.

g/ The investment cost is based upon one-motor drive and 85 feet of steel roller conveyor for two equipment units and is estimated by the equation: Cost per two units = \$325 + \$12.60L, where L = conveyor length in feet.

h/ Includes the installed cost of ten 100-pound line scales--\$1,400; ten filling stands--\$180; one drop roll sizer--\$6,500; and belt, shears, and padded packing bin 60 feet long--\$2,880. The cost of the padded packing bin is estimated at \$13 per foot. The belt and shears cost \$300 for the drive unit plus \$30 per foot in length.

i/ The packed fruit power conveyor is 80 feet long and the replacement cost is estimated by the equation: Cost = \$290 + \$9.58L, where L = conveyor length in feet.

j/ Capacity of this unit depends on the size distribution of the fruit and the number of filling stations. It is based on the capacity of similar equipment for packaging oranges and lemons. On the basis of the smaller fruit size and six filling stations compared with eight for oranges, the capacity is estimated to be approximately one-half the capacity with oranges on a weight basis.

k/ The estimated cost of the automatic filling unit consists of the total of a number of individual cost items. The two largest are the drop roll sizer at \$6,500 and the six carton volume filling units at \$8,500. The cost of a carton shaker unit in the packed fruit conveyor line is included. Costs include sales tax, freight, and installation.

l/ Not applicable.

TABLE 10

Crew and Equipment Reqyirements and Costs of Place-Packing Fresh Plums in Relation to the Method of Packaging, Type of Package Used, and Capacity Rate of Plant Output
California, 1955

Plant capacity	Packaging lines	Job and crew size		Variable costs per hour			Fixed costs					Equations of annual fixed cost and variable cost per hour[g]
		Bin boy[a]	Packer	Labor[b]	Equipment repair and power[c]	Total	Replacement cost		Annual fixed cost[f]		Total annual fixed cost	
							Equipment[d]	Building[e]	Equipment	Building		
crates per hour	number	number of workers		dollars								
Method A--crate, belt pack												
70	1	[h]	10	8.82	.24	9.06	3,075	2,660	455	279	734	
140	1		20	17.64	.31	17.95	4,430	3,815	656	401	1,057	
210	1		30	26.46	.38	26.84	5,790	4,395	857	461	1,318	
280	1		40	35.28	.45	35.73	7,145	4,905	1,058	515	1,573	Annual fixed cost = 615 + 415P
350	2		50	44.10	.66	44.76	9,680	5,830	1,433	612	2,045	
420	2		60	52.92	.72	53.64	10,870	6,760	1,609	710	2,319	
490	2		70	61.74	.78	62.52	12,065	7,045	1,785	740	2,525	Variable cost per hour = .15 + 12.70P
560	2		80	70.56	.84	71.40	13,255	7,895	1,962	829	2,791	
630	3		90	79.38	1.06	80.44	15,790	7,950	2,337	835	3,172	
700	3		100	88.20	1.12	89.32	16,980	8,720	2,513	916	3,429	
770	3		110	97.02	1.18	98.20	18,170	9,490	2,689	996	3,685	
840	3		120	105.84	1.24	107.08	19,360	10,265	2,866	1,078	3,944	
Method B--carton, belt pack												
80	1		10	8.80	.24	9.04	3,075	2,660	455	279	734	
160	1		20	17.60	.31	17.91	4,430	3,815	656	401	1,057	
240	1		30	26.40	.38	26.78	5,790	4,395	857	461	1,318	
320	1		40	35.20	.45	35.65	7,145	4,905	1,058	515	1,573	Annual fixed cost = 615 + 365P
400	2		50	44.00	.66	44.66	9,680	5,830	1,433	612	2,045	
480	2		60	52.80	.72	53.52	10,870	6,760	1,609	710	2,319	
560	2		70	61.60	.78	62.38	12,065	7,045	1,785	740	2,525	Variable cost per hour = .15 + 11.10P
640	2		80	70.40	.84	71.24	13,255	7,895	1,962	829	2,791	
720	3		90	79.20	1.06	80.26	15,790	7,950	2,337	835	3,172	
800	3		100	88.00	1.12	89.12	16,980	8,720	2,513	916	3,429	
880	3		110	96.80	1.18	97.98	18,170	9,490	2,689	996	3,685	
960	3		120	105.60	1.24	106.84	19,360	10,265	2,866	1,078	3,944	
Method C--crate, bin pack												
117	1	1	12	15.79	.11	15.90	1,880	3,550	278	373	651	Annual fixed cost = 430 + 350P
234	2	2	24	31.58	.22	31.80	3,600	4,900	533	515	1,048	
351	3	3	36	47.38	.33	47.71	5,320	6,960	787	731	1,518	
468	4	4	48	63.17	.43	63.60	7,040	8,265	1,042	868	1,910	Variable cost per hour = .50 + 13.55P
585	5	5	60	78.96	.54	79.50	8,760	9,230	1,296	969	2,265	
702	6	6	72	94.75	.64	95.39	10,480	10,950	1,551	1,150	2,701	
Method D--carton, bin pack												
142	1	1	12	15.82	.11	15.93	1,880	3,550	278	373	651	Annual fixed cost = 430 + 290P
284	2	2	24	31.64	.22	31.86	3,600	4,900	533	515	1,048	
426	3	3	36	47.45	.33	47.78	5,320	6,960	787	731	1,518	
568	4	4	48	63.27	.43	63.70	7,040	8,265	1,042	868	1,910	Variable cost per hour = .50 + 11.20P
710	5	5	60	79.09	.54	79.63	8,760	9,230	1,296	969	2,265	
852	6	6	72	94.91	.64	95.55	10,480	10,950	1,551	1,150	2,701	

[a] This worker pulls fruit down into the packing bin making it more available to the packers, pushes crates down the gravity conveyor when necessary, and other miscellaneous jobs as required. One bin boy is provided for each packaging line.

[b] Based on a wage rate of $1.05 per hour for the bin boy and the following piece rates for the crate and carton: 12.6 cents for the crate for both packing methods, 11.0 cents and 10.4 cents per crate equivalent packed in cartons with packing Method A and B respectively. These rates include an allowance of approximately 5 per cent to cover employer's contributions to Social Security and Workmen's Compensation Insurance.

[c] Equipment variable repair expense is estimated at 0.5 per cent of replacement cost per 100 hours use and power at $0.03 per hour per motor horsepower.

[d] With Method A, the cost of the packing belt is estimated by the equation: Cost = 550 + 50L, where L = length of the belt unit in feet. L is estimated by: L = 5 + 1.75W, where W = the number of packers.

[e] The building replacement cost is for the area required for the packers and packing equipment only. The replacement cost is based on an average cost per square foot that depends on size of building. See Table 20.

[f] Based on an annual percentage of replacement cost. See Appendix Table C for the basis and the amount of this charge for each type of equipment and for the building.

[g] P = plant capacity in 100 crate equivalents packaged per hour.

[h] Blanks indicate job not required for this method.

TABLE 11

Crew and Equipment Requirements and Costs of Bulk-Filling Plums in Packages in Relation to the Method of Filling and Capacity Rate of Plant Output. California, 1955

Plant capacity	Equipment units	Packaging workers	Variable costs per hour			Fixed costs					Equations of annual fixed cost and variable cost per hour[e]
						Replacement costs		Annual fixed costs[d]		Total annual fixed cost	
			Packaging labor[a]	Equipment repair and power[b]	Total	Equipment	Building[c]	Equipment	Building		
crates per hour	number	number	dollars	dollars	dollars	dollars	dollars	dollars	dollars	dollars	
	Method E--rope sizing, bulk fill										
75	1	1	1.05	.10	1.15	2,360	2,165	349	227	576	
150	1	2	2.10	.10	2.20	2,360	2,165	349	227	576	
225	1	3	3.15	.10	3.25	2,360	2,165	349	227	576	
300	1	4	4.20	.10	4.30	2,360	2,165	349	227	576	
375	1	5	5.25	.10	5.35	2,360	2,165	349	227	576	Annual fixed cost = 340 + 125P
450	2	6	6.30	.20	6.50	4,720	3,116	698	327	1,025	
525	2	7	7.35	.20	7.55	4,720	3,116	698	327	1,025	
600	2	8	8.40	.20	8.60	4,720	3,116	698	327	1,025	Variable cost per hour = .60 + 1.41P
675	2	9	9.45	.20	9.65	4,720	3,116	698	327	1,025	
750	2	10	10.50	.20	10.70	4,720	3,116	698	327	1,025	
825	3	11	11.55	.30	11.85	7,080	4,428	1,047	465	1,512	
900	3	12	12.60	.30	12.90	7,080	4,428	1,047	465	1,512	
975	3	13	13.65	.30	13.95	7,080	4,428	1,047	465	1,512	
1,050	3	14	14.70	.30	15.00	7,080	4,428	1,047	465	1,512	
1,125	3	15	15.75	.30	16.05	7,080	4,428	1,047	465	1,512	
	Method F--drop-roll sizing, bulk fill										
75	1	1	1.05	.62	1.67	12,015	2,960	1,778	311	2,089	
150	1	2	2.10	.62	2.72	12,015	2,960	1,778	311	2,089	
225	1	3	3.15	.62	3.77	12,015	2,960	1,778	311	2,089	
300	1	4	4.20	.62	4.82	12,015	2,960	1,778	311	2,089	
375	1	5	5.25	.62	5.87	12,015	2,960	1,778	311	2,089	
450	1	6	6.30	.62	6.92	12,015	2,960	1,778	311	2,089	
525	1	7	7.35	.62	7.97	12,015	2,960	1,778	311	2,089	Annual fixed cost = 1,050 + 275P
600	1	8	8.40	.62	9.02	12,015	2,960	1,778	311	2,089	
675	1	9	9.45	.62	10.07	12,015	2,960	1,778	311	2,089	
750	1	10	10.50	.62	11.12	12,015	2,960	1,778	311	2,089	Variable cost per hour = 1.10 + 1.43P
825	2	11	11.55	1.24	12.79	24,030	5,770	3,556	606	4,162	
900	2	12	12.60	1.24	13.84	24,030	5,770	3,556	606	4,162	
975	2	13	13.65	1.24	14.89	24,030	5,770	3,556	606	4,162	
1,050	2	14	14.70	1.24	15.94	24,030	5,770	3,556	606	4,162	
1,125	2	15	15.75	1.24	16.99	24,030	5,770	3,556	606	4,162	
1,200	2	16	16.80	1.24	18.04	24,030	5,770	3,556	606	4,162	
1,275	2	17	17.85	1.24	19.09	24,030	5,770	3,556	606	4,162	
1,350	2	18	18.90	1.24	20.14	24,030	5,770	3,556	606	4,162	
1,425	2	19	19.95	1.24	21.19	24,030	5,770	3,556	606	4,162	
1,500	2	20	21.00	1.24	22.24	24,030	5,770	3,556	606	4,162	
	Method G--automatic bulk fill										
750	1		[f]	1.57	1.57	27,445	2,880	4,062	302	4,364	Annual fixed cost = 2150 + 580P
1,500	2			3.14	3.14	54,890	5,616	8,124	590	8,714	Variable cost per hour = .78 + .21P

[a] Based on a wage rate of $1.05 per hour which includes an allowance of approximately 5 per cent of worker's pay for employer's contribution to Social Security, Workmen's Compensation Insurance, and other worker benefits.

[b] Equipment variable repair estimated at 0.5 per cent of replacement cost per 100 hours use and power at $0.03 per hour per motor horsepower.

[c] The building replacement cost is for the area required for the packagers and packaging equipment only. The replacement cost is based on an average cost per square foot depending on the building size. For Method F and G, this cost is estimated at $2.00 per square foot for the plant with one equipment unit and $1.95 per square foot for the plant with two equipment units.

[d] Based on an annual charge of 14.8 per cent of replacement cost for equipment and 10.5 per cent for the building. See Appendix Table C for the basis of these charges.

[e] P = plant capacity in 100 crate equivalents packaged per hour.

[f] Labor for machine attendance is provided for in the direct supervision component.

Total Season Costs

As in preceding stage analyses, equations relating annual fixed cost and variable costs per hour to rate of plant output as given in Tables 10 and 11 are used to estimate total packing cost in plants of given size operating a specified number of hours per season. Total season costs computed in this way for seasons of 100, 300, and 500 hours are shown graphically in Figure 11. Each panel of the chart also gives for the different methods an equation relating total cost in a season of the length specified to rate of packed output.

For the lengths of season considered in Figure 11, all methods of bulk-fill are considerably less costly than place-pack methods except in plants of extremely low output rate. Of the place-packing methods, costs with the standard crate are consistently higher than with crate-equivalent volumes packed in cartons. There is little difference in cost between place-packing with bin- or belt-type equipment.

Among the bulk-filling methods, the low-cost technique over most of the ranges in season length and output rate considered is method E, involving the use of rope-sizing equipment in conjunction with bulk bins. The cost advantage of this method as compared with method F--the bulk bin with drop-roll sizer--is to be expected, since the essential difference between these methods is the use of a more expensive sizing machine with higher annual fixed charges for method F as compared with method E. Selection of method F, therefore, would be justified only if there were sufficiently large additional economies resulting from improved quality of sizing. Method G--involving automatic packaging and high fixed costs for equipment--becomes more economical as length of season increases. Even with a 500-hour season, method G becomes lowest in cost only in plants of relatively large capacity.[1]

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[1] The above comparisons of packaging cost are based on "smoothed" cost equations. This is satisfactory for place-packing methods, but with bulk-filling methods--particularly with automatic packaging--the large investment cost of one equipment unit causes large discontinuities in the equations for season cost. To estimate the effect of this on the selection of the lowest cost packaging methods, season costs with the bulk-fill packaging methods were calculated for closely spaced output intervals from the variable costs per hour and annual fixed costs given in Table 11. Method E, using rope sizing equipment with padded bins, gave the lowest season cost for 100- and 300-hour seasons--the same result obtained with smoothed equations. With a 500-hour season, automatic packaging, method G, gave lowest cost at output rates from about 530 to 750 and from 1,200 to 1,500 crate equivalents per hour. Bins with rope sizing gave lower cost for the other output rates. For simplicity, the smoothed equations of variable cost per hour and annual fixed cost--developed and given in Table 11--are used to estimate total season costs of packaging in Figure 11 and total plant costs in a later section.

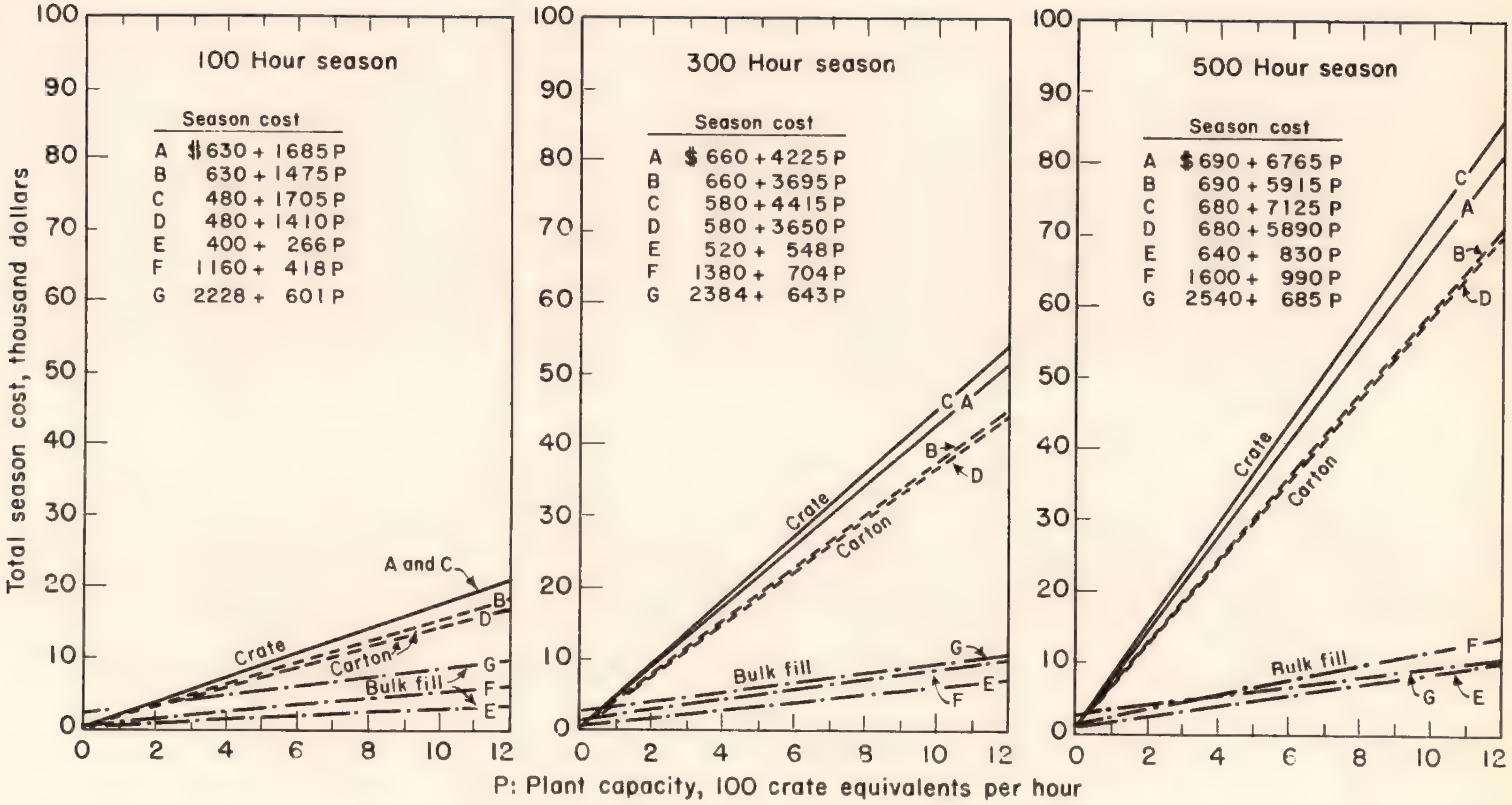

Figure 11. Total Season Costs of Packaging Plums in Relation to Method of Packaging, Length of Season, and Plant Capacity Output Rate. California Plums, 1955.

Container Making

In this section, costs with different methods of fabricating the standard crate and the fiberboard carton are considered. Additional labor involved in crate but not carton fabrication includes pasting labels and--for the large-size fruit--nailing a cleat to the crate ends to provide a deeper container.

Methods and Equipment Used

Four different methods of making the standard crate and two types of carton forming are considered as follows.

Method A: Crates. Shook materials (crate components) are assembled in a simple jig, or nailing stand, and nailed manually. Shook is supplied from a temporary storage point by the crate maker.

Method B: Crates. This involves manual assembly of shook materials into a stitcher-type nailing machine that drives one nail per machine cycle into each end of the crate. A shook boy assists the crate maker by supplying shook from nearby temporary storage.

Method C: Crates. The shook materials are placed manually into a standard nailing machine equipped to complete the nailing of either the bottom or a side of the crate on each cycle of the nailing head. Supply of shook from a temporary storage point is performed by a helper.

Method D: Crates. With this method, the procedure is the same as with method C, except that the crate ends are fed into the nailing machine automatically.

Method E: Stapled carton. Flat carton assemblies are folded manually and the bottom flaps stapled in a stapling machine. Two-inch flaps at the top of the carton are turned out and down, and a full-depth liner is folded and inserted. The carton cover is folded, but not stapled.

Method F: Full telescoped carton. With this method, both the bottom and full-telescope cover are folded manually; neither is stapled.

Labor and Equipment Requirements and Costs

Production standards for making the crate are based on time and production studies of such operations in a variety of deciduous fruit packing houses, while standards for assembly of the carton are based on relatively limited studies in plum packing houses. The standards are based on labor performance with piece-rate

wage plans in crate fabrication and hourly-rate wages for carton assembly.[1] These standards and estimates of crew and equipment requirements, and of variable and fixed costs in relation to output rate with the various methods of crate and carton fabrication are given in Table 12. As in previous stage analyses, the costs given in the table are used to develop equations of variable cost per hour and annual fixed cost. These equations, given in the last column of Table 12, are then used to develop the estimates of total cost in relation to output rate shown graphically in Figure 12 for seasons of 100, 300, and 500 hours' operation. Each panel of this chart also gives for each method an equation relating total cost for the length of season specified to rate of output in this stage.

For crate fabrication, Figure 12 shows that method A, which involves a minimum of mechanization, is most economical for an operating season of 100 hours. With seasons of greater length, mechanized methods of crate making become economical. With an operating season of 300 hours, method A gives lowest cost in plants of capacities less than 260 crates per hour while method C, using the standard nailing machine, is lowest in cost for plant capacities from 260 to 570 crates per hour. For plant capacities greater than 570 crates per hour method D, which uses automatic end feed and nailing of the crate, is lowest in cost. A similar pattern applies with a 500-hour season, except that the shifts in method occur at lower output rates.

With carton assembly, Figure 12 shows method E--in which the stapled carton and folded cover is used--to be lowest in cost over the ranges in plant size and length of season considered, except in small plants with short-season operation.

Empty Container Supply

This stage includes the movement of empty containers from point of fabrication to the packaging stations. The analysis is developed initially in terms of procedures and costs regarding container supply operations in place-packing the standard crate. The results then are modified for application to carton-supply operations. Attention also is given--on a simplified basis--to the supply of containers for bulk-fill operations.

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[1] Almost without exception, a piece-rate wage was paid for labeling, making, and cleating the crate. This presumably reflects a desire to maximize output from each nailing machine and thus reduce plant investment.

TABLE 12

Container-Making Crew and Equipment Requirements and Costs in Relation to Output Rate. Packing California Plums, 1955

Plant capacity	Job and crew size[a]		Variable costs per hour				Fixed costs		Equations of annual fixed cost and variable cost per hour[g]
	Container makers	Crate shook worker or carton helper	Container making[b]	Label and cleat[c]	Equipment repair and power[d]	Total	Equipment replacement cost[e]	Average annual fixed cost[f]	
containers per hour	number of workers		dollars						
			Method A--manual crate making						
59	1	[h]	1.18	.24	[i]	1.42	50	6	Annual fixed cost = 3 + 10P Variable cost per hour = 2.41P
118	2		2.36	.47	.01	2.84	100	12	
177	3		3.54	.71	.01	4.26	150	18	
236	4		4.72	.94	.01	5.67	200	24	
295	5		5.90	1.18	.01	7.09	250	30	
354	6		7.08	1.42	.02	8.52	300	36	
413	7		8.26	1.65	.02	9.93	350	42	
			Method B--stitcher machine						
250	1	1	4.30	1.00	.12	5.42	1,850	244	Annual fixed cost = 122 + 98P Variable cost per hour = 1.96P
500	2	1	7.55	2.00	.24	9.79	3,700	488	
750	3	2	11.85	3.00	.36	15.21	5,550	732	
1,000	4	2	15.10	4.00	.48	19.58	7,400	976	
1,250	5	3	19.40	5.00	.60	25.00	9,250	1,220	
1,500	6	3	22.65	6.00	.72	29.37	11,100	1,464	
			Method C--standard machine						
430	1	1	5.78	1.72	.21	7.71	3,590	474	Annual fixed cost = 237 + 110P Variable cost per hour = 1.77P
500	2	1	6.55	2.00	.42	8.97	7,180	948	
860	2	2	10.56	3.44	.42	14.42	7,180	948	
1,000	3	2	13.10	4.00	.63	17.73	10,770	1,422	
1,290	3	3	17.34	5.16	.63	23.13	10,770	1,422	
			Method D--end-feed machine						
500	1	1	6.05	2.00	.27	6.32	4,860	642	Annual fixed cost = 321 + 128P Variable cost per hour = 1.66P
1,000	2	2	12.10	4.00	.54	12.64	9,720	1,284	
1,500	3	3	18.15	6.00	.81	18.96	14,580	1,926	
			Method E--stapled carton						
71	1		1.05		.04	1.09	525	69	Annual fixed cost = 35 + 25V Variable cost per hour = .63 + 1.60V
95	1	1	2.10		.04	2.14	525	69	
190	1	2	3.15		.04	3.19	525	69	
280	1	3	4.20		.04	4.24	525	69	
285	2	3	5.25		.08	5.33	1,050	138	
380	2	4	6.30		.08	6.38	1,050	138	
475	2	5	7.35		.08	7.43	1,050	138	
560	2	6	8.40		.08	8.48	1,050	138	
			Method F--telescope carton						
51	1		1.05		[f]	1.05	25	3	Annual fixed cost = 2 + 6V Variable cost per hour = .53 + 2.06V
102	2		2.10		[f]	2.10	50	7	
153	3		3.15		[f]	3.15	75	10	
204	4		4.20		.01	4.21	100	13	
255	5		5.25		.01	5.26	125	16	
306	6		6.30		.01	6.31	150	20	

[a] The crew organization for Method E uses one worker for the entire carton making and stacking operation up to his capacity rate of 71 cartons per hour. Beyond this rate, other workers are required and the standard for folding the bottom of the carton and stapling is 280 cartons per hour. Other standards for making (containers per hour): Method A--59; Method B--250; Method C--430; and Method D--500. For the shook worker, the labor standard is 500 crates per hour. The labor standard for the carton helper, Method E, who performs all operations except folding and stapling the bottom of the carton is 95 cartons per hour.

[b] For making the crate, the piece rates per 100 crates are: Method A--$2.00; Method B--$1.30; Method C--$1.10; Method D--$1.00. The carton maker, carton helper, and shook worker are paid $1.05 per hour. All piece rates and wage rates include an allowance of approximately 5 per cent for employer's contributions to Social Security and Workmen's Compensation Insurance.

[c] Includes an allowance of $0.30 per 100 crates for each of the operations of labeling and cleating. Since about one-third of the crates are cleated, the average cost per 100 crates is estimated at $0.40 per 100 crates.

[d] Variable equipment repair estimated at 0.5 per cent of replacement cost per 100 hours of use and power at $0.03 per hour per motor horsepower.

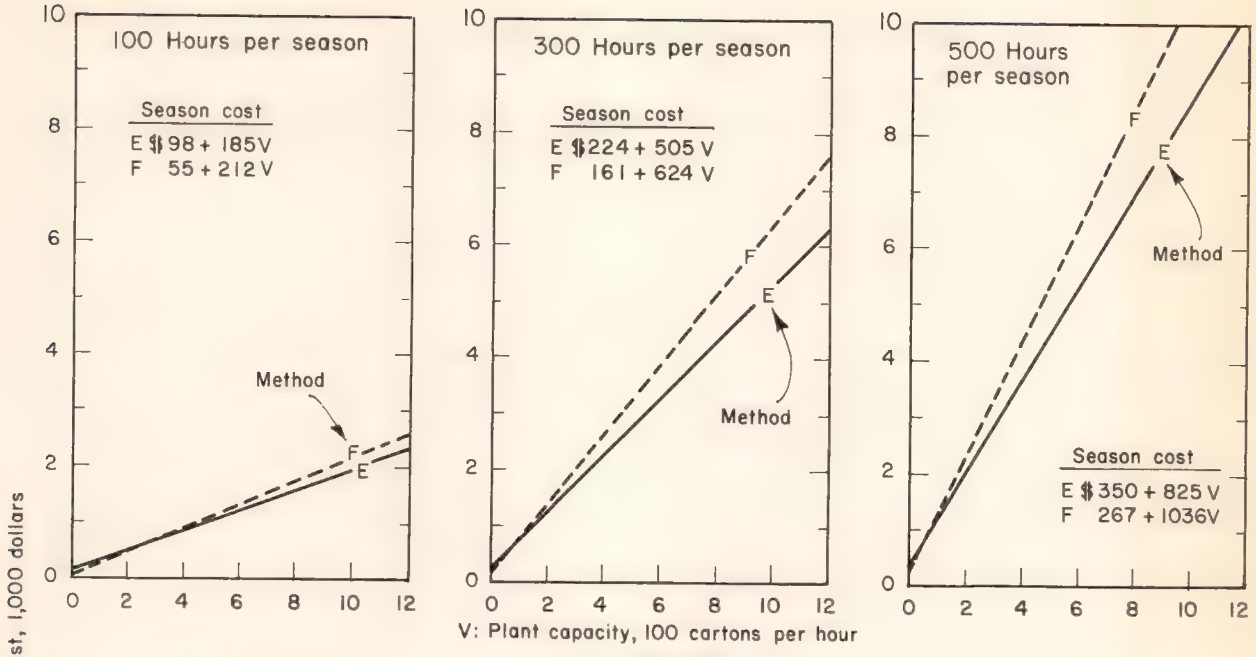
[e] Based on the following equipment items and replacement costs: Method A, shook holder and making stand--$50; Method B, stitcher machine--$1,850; Method C, standard nailing machine--$3,590; Method D, end-feed machine--$4,860; Method E, stapling machine--$500; carton folding stand--$25; and Method F, carton folding stand--$25.

[f] Based on a percentage charge of replacement cost of 11.5 per cent for Method A and 13.2 per cent for the other methods. See Appendix Table C for the details.

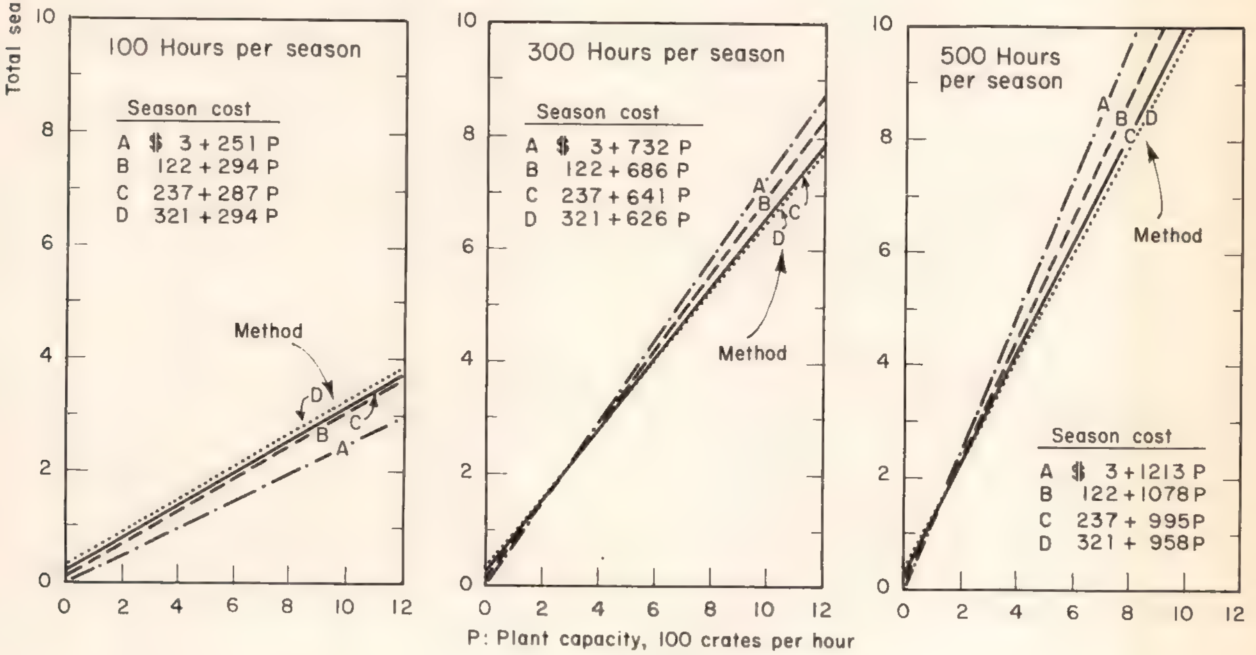
[g] P and V = plant capacity in 100 crates per hour and 100 cartons per hour respectively.

[h] Blanks indicate job not performed with this method.

[i] Less than $0.005.



A. CARTONS



B. CRATES

Figure 12. Total Season Costs of Container Making in Relation to Methods Used, Capacity Output Rate and Length of Operating Season, Packing California Plums, 1955.

Container Supply Methods

While the container supply operations are similar for the different types of containers and packaging methods, there are differences in detail that affect costs. In most circumstances, for example, perfect integration in the rate of container fabrication and their use is not realized so that a portion of the assembled containers may be diverted to temporary storage during slack packing periods. This reserve supply is then drawn on during peak packing periods. With cartons, an estimated 20 per cent of the total containers packed are handled in this way as compared with roughly 50 per cent for the standard crate. The higher percentage with crates results from the fact that two different crate sizes--as compared with one carton size--must be available to the packers to accommodate the range in fruit sizes usually packed. To avoid excessive frequency in nailing machine adjustment, there is a higher proportion of crates than cartons assembled for inventory rather than immediate use.[1]

Furthermore, equipment requirements are somewhat lower in the supply of cartons for place-packing and bulk-filling as compared with the crate. The lower equipment requirements are largely the result of higher rates of packer output in place-packing and bulk-filling the carton. Fewer packers and less container supply equipment are required for a given rate of output.

Costs with five methods of container supply are considered. The last of the methods listed below is considered only in container supply for bulk-fill, while the remaining methods are considered for the supply of either crates or cartons in place-pack operations. Procedures with these methods are as follows.

Method A: Hand truck supply. With this method, containers moving on a gravity conveyor from the container assembly point are set off and stacked. The stacked containers are trucked to the end of the packing lines then transferred to and pushed down gravity conveyors leading to the packers. Excess containers are trucked to a temporary storage then to the packing lines as needed.

Method B: Monorail conveyor. Containers on a gravity conveyor from the container assembly point are transferred to hooks on an overhead monorail conveyor which carries them through the packing area. Excess crates are set off and stacked nearby then transferred to the monorail as needed.

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[1] These percentages may not be appropriate for a given plant, but substantial departures from these percentages would not significantly affect relative costs with different methods.

Method C: Mezzanine fabrication and supplies. All container fabrication and supply operations are performed on a mezzanine. Containers move by gravity conveyor directly from assembly points to chutes leading to conveyors along the packing lines. Individual containers are transferred manually from mezzanine conveyor to chute or placed in nearby temporary storage as required.[1]

Method D: Basement supply. Container fabrication and storage are performed in the basement. Assembled containers are elevated to the packing-floor level and discharged directly onto conveyors to the packers.

Method E: Bulk-fill container supply. With this method, containers are set off and stacked from the container maker. They are then hand trucked from this area to a set-on point and transferred to a conveyor leading to the filling stations.[2]

Labor and Equipment Requirements and Costs

Equipment requirements with a given method in the carton-supply operations depend primarily on plant layout and on the capacities and dimensions of the packaging equipment used. The types and quantities of equipment required with the various methods are given in Table 13.

Labor requirements are estimated from plant time and production studies. Some of the carton-supply jobs involve several different operations--for example, with method A, trucking stacked containers and feeding containers to conveyors to the packers may be performed by a single worker. In some cases, unit times were estimated for the individual operations (given in Appendix Table A) and then combined to give an estimate for the composite job (Table 14).

Production standards for the container supply operations are used to estimate the crew and equipment requirements and costs for each of the methods in relation to rate of output (Table 14).[3] The equations given in the table are then used to estimate total season costs of the container supply operation. These cost relationships are shown graphically in Figure 13 and indicate the low-cost method in relation to rate of output for three lengths of season.

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[1] Provision of a container mezzanine reduces space requirements at the packing floor level. The resulting reduction in building cost is approximately equal to the added costs of mezzanine construction.

[2] Although other methods of container supply are available for bulk-filling operations, only one method is considered.

[3] The equipment requirements and costs for the distribution of empty containers for place-packing are based on the use of belt-tvpe packaging equipment. Very little difference would, however, be found in regard to each method if its use with bin-type equipment were considered. Consequently, specific results are given only with respect to belt-type equipment.

TABLE 13

Quantities and Replacement Costs of Major Equipment Units Required with
Different Methods of Container Distribution.
Packing California Plums, 1955

Item	Description and quantity	Unit	Replacement costs	Methods applicable to
			dollars	
Conveyor from container maker	Sidewheel, 20 feet per 500 container capacity	per foot	4.00	A, B, and D
	One-level roller conveyor, 10 feet plus 20 feet per container supply line	per foot	7.50	C
	Cross-bar type, two-level elevator including a limit switch at end of container conveyor, one per packing line	each	665.00	D
Container chute	Two-level chute from mezzanine to the two-level supply conveyors alongside the packers, one per packing line	each	120.00	C
Conveyors alongside packers				
Gravity, two level				
Belt packing (crate)	For each packing line 1.75 feet of wheeled conveyor per packer (maximum of 40 packers per line, conveyor centered over the packing line)	per foot	8.00	A, C, and D
Bin packing (crate)	For first packing line 6 feet of wheeled conveyor per packer (12 packers per line), three feet per packer on additional lines	per foot	8.00	A, C, and D
Gravity, single level				
Belt packing (carton)	For each packing line 1.75 feet of wheeled conveyor per packer (maximum of 40 packers per line, conveyor centered over the packing line)	per foot	5.00	A and C
Bulk packaging	Roller conveyor, 4 feet per worker bulk-filling packages	per foot	7.50	E
Monorail				
Crate and carton	Layout of packing lines similar to that with other container supply methods. Monorail conveyor runs between and along the outside of the packing lines. In addition, 20 feet of monorail conveyor required from the crate set-on station to the first packing line, plus 20 feet between each additional packing line and plus return from the last packing line back to the container set-on station	each	410.00 plus 5.30 per foot length	B
Hand truck	One per trucker	each	90.00	A, B, D, and E

TABLE 14

Crew and Equipment Requirements and Costs of Supplying Containers.
Packing California Plums, 1955

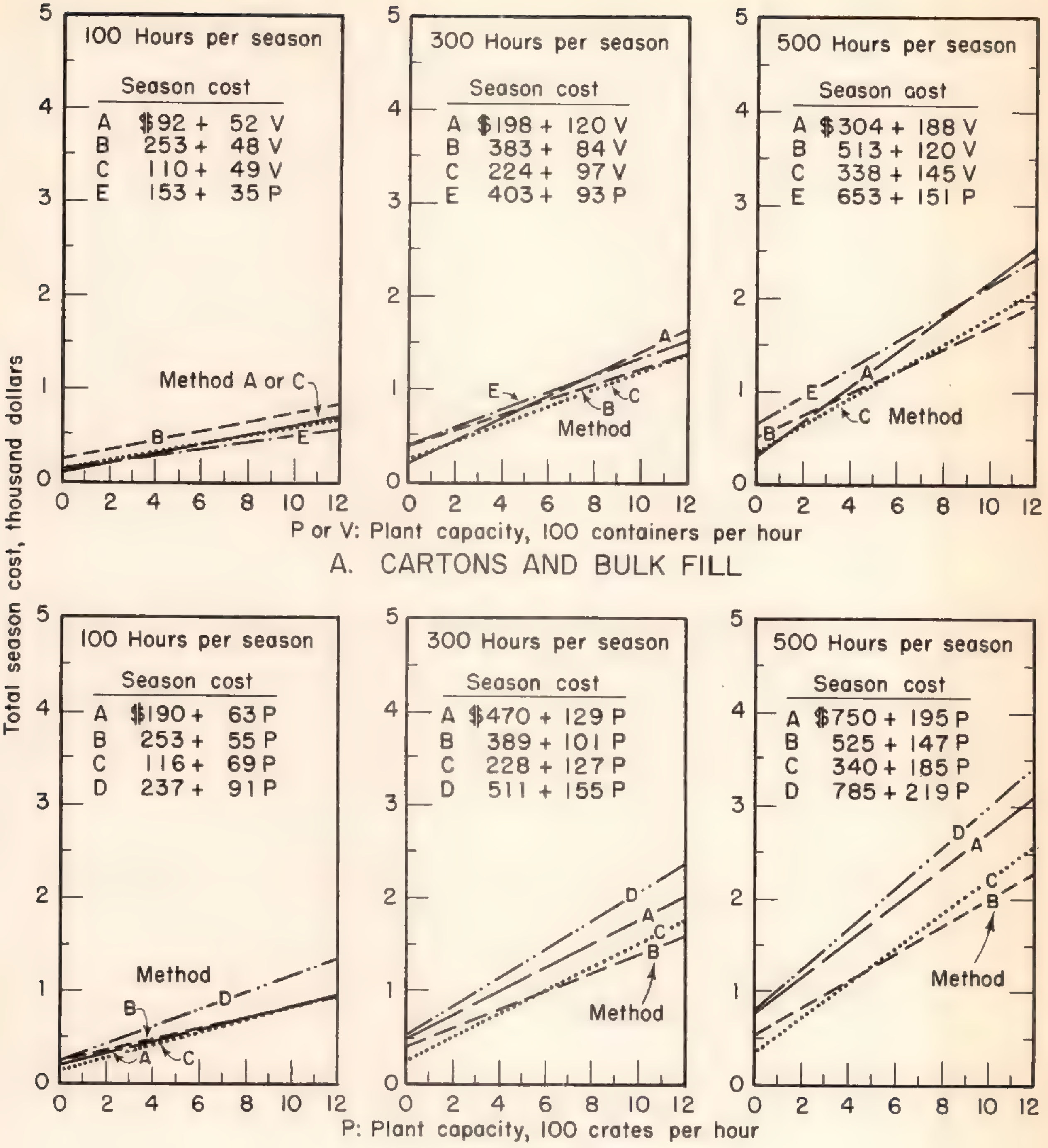
Container supply method and production standard	Crew required in relation to capacity output rate		Variable costs per hour			Fixed costs		Equations of annual fixed cost and variable cost per hour[d]
	Plant capacity	Crew size	Labor[a]	Equipment repair and power[b]	Total	Equipment replacement cost	Annual fixed cost[c]	
	crates per hour	number of workers	dollars					
CRATES								
Method A--Hand truck supply								
Set off and stack packed crates 16 high (production standard, 1,000 crates per man-hour); and hand truck one-half of total volume directly to packer supply conveyor and transfer crates to conveyor, hand truck remaining crates 30 feet to temporary storage, and then 60 feet to packer supply conveyor as needed (production standard, 425 crates per man-hour).	280	2	2.10	.04	2.14	730	96	Annual fixed cost = 50 + 30P Variable cost per hour = 1.40 + .33P
	425	2	2.10	.06	2.16	1,290	170	
	500	3	3.15	.06	3.21	1,290	170	
	560	3	3.15	.07	3.22	1,370	181	
	750	3	3.15	.10	3.25	1,930	255	
	840	3	3.15	.10	3.25	2,020	267	
	850	3	3.15	.13	3.28	2,580	341	
	1,000	4	4.20	.13	4.33	2,580	341	
	1,120	5	5.25	.13	5.38	2,660	351	
Method B--Monorail conveyor								
Transfer one-half of crates directly from conveyor from crate maker to hook on monorail conveyor, set off and stack remaining crates in nearby temporary storage, and then transfer to monorail conveyor as needed (production standard, 480 crates per man-hour).	280	1	1.05	.11	1.16	1,760	233	Annual fixed cost = 185 + 32P Variable cost per hour = .68 + .23P
	480	1	1.05	.15	1.20	2,395	317	
	500	2	2.10	.15	2.25	2,395	317	
	560	2	2.10	.16	2.26	2,475	328	
	840	2	2.10	.20	2.30	3,110	411	
	880	2	2.10	.24	2.34	3,745	495	
	960	2	2.10	.25	2.35	3,835	506	
	1,000	3	3.15	.25	3.40	3,835	506	
	1,120	3	3.15	.26	3.41	3,915	517	
Method C--Mezzanine fabrication and supply								
Transfer one-half of crates directly from mezzanine conveyor from crate maker to packer supply chute, set off the remaining crates to nearby temporary storage, and return them to chute as needed (production standard, 375 crates per man hour).	280	1	1.05	.05	1.10	905	119	Annual fixed cost = 60 + 40P Variable cost per hour = .56 + .29P
	375	1	1.05	.09	1.14	1,735	229	
	560	2	2.10	.09	2.19	1,735	229	
	750	2	2.10	.13	2.23	2,565	339	
	840	3	3.15	.13	3.28	2,565	339	
	1,120	3	3.15	.17	3.32	3,395	448	
Method D--Basement supply								
Set off and stack crates 16 high (production standard, 1,000 crates per man-hour); and hand truck one-half of crates 30 feet directly to crate elevator and transfer crates individually to elevator, truck remaining crates 30 feet to temporary storage, and then 30 feet to elevator as needed (production standard, 470 crates per man-hour).	280	2	2.10	.08	2.18	1,395	184	Annual fixed cost = 100 + 59P Variable cost per hour = 1.37 + .32P
	470	2	2.10	.15	2.25	2,620	346	
	500	3	3.15	.15	3.30	2,620	346	
	560	3	3.15	.16	3.31	2,700	356	
	840	3	3.15	.23	3.38	3,925	518	
	900	3	3.15	.30	3.45	5,150	680	
	940	3	3.15	.30	3.45	5,240	692	
	1,000	4	4.20	.30	4.50	5,240	692	
	1,120	5	5.25	.31	5.56	5,320	702	
PLACE-PACK CARTONS								
Method A--Hand truck supply								
Set off and stack empty cartons, hand truck 80 per cent of total volume directly to packer supply conveyor and transfer cartons individually to conveyor, hand truck remaining cartons 30 feet to temporary storage, and then 60 feet to packer supply as needed (production standard, 310 cartons per man-hour).	310	1	1.05	.03	1.08	520	69	Annual fixed cost = 39 + 18V Variable cost per hour = .53 + .34V
	320	2	2.10	.03	2.13	520	69	
	500	2	2.10	.04	2.14	870	115	
	620	2	2.10	.05	2.15	950	125	
	640	3	3.15	.05	3.20	950	125	
	750	3	3.15	.07	3.22	1,300	172	
	930	3	3.15	.07	3.22	1,390	183	
	960	4	4.20	.07	4.27	1,390	183	
	1,000	4	4.20	.09	4.29	1,740	230	
	1,240	4	4.20	.09	4.29	1,820	240	
Method B--Monorail conveyor								
The job is the same as with the standard crate (see above), except that only 20 per cent of the total cartons handled are diverted to temporary storage (production standard, 630 cartons per man-hour).	320	1	1.10	.11	1.21	1,850	244	Annual fixed cost = 188 + 30V Variable cost per hour = .65 + .18V
	500	1	1.10	.15	1.25	2,485	328	
	630	1	1.10	.16	1.26	2,565	339	
	640	2	2.10	.16	2.26	2,565	339	
	900	2	2.10	.20	2.30	3,200	422	
	960	2	2.10	.20	2.30	3,290	434	
	1,000	2	2.10	.25	2.35	3,925	518	
	1,260	2	2.10	.25	2.35	4,005	529	
Method C--Mezzanine fabrication and supply								
The job is the same as with the standard crate (see above), except that only 20 per cent of the total cartons handled are diverted to temporary storage (production standard, 450 cartons per man-hour).	320	1	1.10	.03	1.13	695	92	Annual fixed cost = 53 + 25V Variable cost per hour = .57 + .24V
	450	1	1.10	.07	1.17	1,315	174	
	640	2	2.10	.07	2.17	1,315	174	
	900	2	2.10	.10	2.20	1,935	255	
	960	3	3.15	.10	3.25	1,935	255	
	1,280	3	3.15	.13	3.28	2,555	337	
BULK-FILL CONTAINERS								
Method E								
From container maker, set off and stack containers 16 high (production standard, 1,000 containers per man-hour); and hand truck 16 high stacks 60 feet and transfer to container supply conveyor (production standard, 510 containers per man-hour).	510	2	2.10	.02	2.12	390	51	Annual fixed cost = 28 + 6P Variable cost per hour = 1.25 + .29P
	750	3	3.15	.02	3.17	390	51	
	1,000	3	3.15	.03	3.18	690	91	
	1,020	4	4.20	.03	4.23	690	91	
	1,280	5	5.25	.03	5.28	690	91	

[a] Based on a wage rate of $1.05 per hour which includes an allowance of approximately 5 per cent for employer's contributions to Social Security and Workman's Compensation Insurance.

[b] Equipment variable repair estimated at 0.5 per cent of replacement cost per 100 hours use and electric power at $0.03 per hour per motor horsepower.

[c] Estimated at 13.2 per cent of replacement cost. See Appendix Table C for the basis of this annual charge.

[d] P = plant capacity in 100 crates per hour and V = plant capacity in 100 cartons per hour.



A. CARTONS AND BULK FILL

B. CRATES

Figure 13. Total Season Costs Of Supplying Containers To The Packers As Affected By Rate And Method Of Supply, Type Of Container, And Length Of Operating Season In Packing California Plums, 1955.

Direct Clerical Labor

Direct clerical labor includes the following types of work: (1) stamping on each container such information as the size of fruit, minimum net weight, fruit variety, and federal-state inspection markings; (2) placing a top pad on each container; and (3) tallying the number of containers packed with respect to fruit size and as to grower and packer identity. The particular operations performed and the crew organization used varies among plants. Generally only two--but in a few plants three--stamping operations are performed. In some plants side liners, which fold over the top of the fruit, are substituted for the top pad. Two tally operations may be performed by a single worker, or these operations may be specialized. Since variations in costs with the different procedures available are minor, production standards and costs are presented only for the situation most frequently encountered. This involves two separate stamping operations, placing a top pad, and two tally operations.

Data as to labor production standards, and equipment requirements as well as estimates of crew organization and variable and fixed costs in relation to output rate based on these standards are given in Table 15. The table also gives simple equations relating these cost categories to rate of plant output. The equations of variable and annual fixed cost are the basis of estimated total cost in seasons of selected length shown graphically in Figure 14. The chart also contains equations relating total cost in seasons of specified length to rate of output.

Container Closing

Five different methods of closing the packed container are described below. The first four methods pertain to placing a slatted wood cover on the standard crate, while the fifth method relates to closing the fiberboard carton. The closing procedures are as follows:

Method A: Hand lidding. The packed crate and lid are placed in a foot-operated press, which holds them in place while the lidder drives three nails in each end of the crate.

Method B: Stitcher lidding. The packed crate and lid are assembled in a nailing machine called a stitcher. As the crate is pushed through the machine by the operator, one nail is driven in each end of the crate on each of three cycles of the nailing head.

TABLE 15

Costs of Direct Clerical Labor and Associated Equipment in Relation to Rate of Plant Output. Packing California Plums, 1955

Plant capacity	Crew[a/]		Variable costs per hour			Fixed costs		Equations of annual fixed cost and variable cost per hour[f/]
	Stamp, place top pad	Tally	Labor[b/]	Equipment repair[c/]	Total	Equipment replacement cost[d/]	Average annual fixed cost[e/]	
containers per hour	number of workers		dollars					
0- 290	1	1	1.90	g/	1.90	35	5	
291- 340	2	1	2.85	g/	2.85	55	7	
341- 580	2	2	3.80	g/	3.80	70	9	Annual fixed cost = 3 + 1P
581- 680	3	2	4.75	g/	4.75	90	12	
681- 870	3	3	5.70	.01	5.71	105	14	Variable cost per hour = 1.03 + .60P
871-1,020	4	3	6.65	.01	6.66	125	17	
1,021-1,160	4	4	7.60	.01	7.61	140	18	
1,161-1,360	5	4	8.55	.01	8.56	160	21	

a/ Labor standards (containers per hour): two-stamp operation, place top pad--290; single-tally operation--680; and two-tally operation--340.

b/ Based on a wage rate of $0.95 per hour for the stamper and $1.05 per hour for the tally worker. This includes an allowance of approximately 5 per cent for employer's contributions to Social Security and Workmen's Compensation Insurance.

c/ Equipment variable repair estimated at 0.5 per cent of replacement cost per 100 hours use.

d/ Based on one stamp stand and stamps per stamper at $20 each and one tally desk and materials per tally worker at $15 each.

e/ Based on an annual charge of 13.2 per cent of replacement cost. See Appendix Table C for the basis and details of this charge.

f/ P = plant capacity in 100 crates per hour.

g/ Less than $0.005.

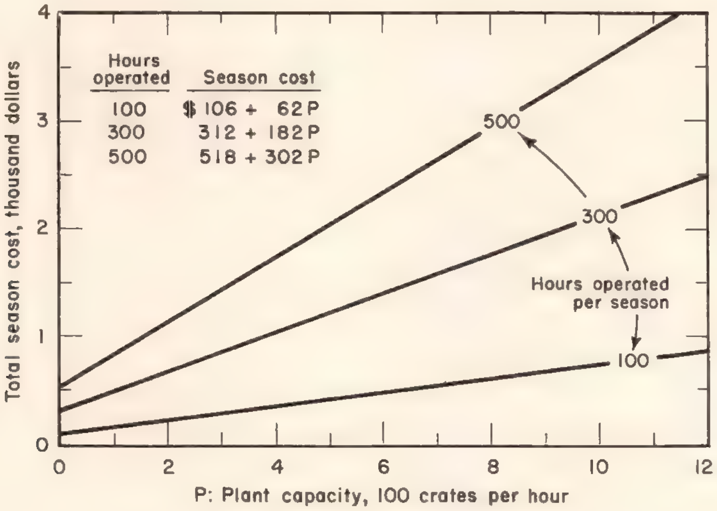


Figure 14. Total Season Cost of Direct Clerical Operations in Relation to Plant Capacity in Crates Per Hour and Length of Operating Season. Packing California Plums, 1955.

Method C: Standard lidding. An operator pushes a packed crate into a standard nailing machine, inserts a lid, and depresses a foot pedal to operate the nailing head. All nails are driven in one machine cycle. Most machines automatically eject the lidded crate.

Method D: High-speed lidding. The operator feeds a lid into a semi-automatic nailing machine, while an accumulator conveyor feeds in the packed crate. All nails are driven in a single machine cycle and the crate is ejected automatically.

Method E: Carton closing. Details as to container closure vary with the particular carton design. The one method considered here involves pushing a self-locking lid down over the top of a carton provided with 2-inch flaps that are folded out and down at the top of the carton so as to interlock with the top.

Labor and equipment production standards for the operations involved with the above methods are presented in Table 16, which also gives for each method the estimated crew requirements and crew and equipment costs with several levels of output rate. These data are used to compute variable cost per hour for labor and other services and to estimate an annual fixed charge for equipment at each output rate considered. Equations derived from these results which relate variable cost per hour and annual fixed charge to rate of packed output are also given in the table. These equations are the basis of estimated total cost in relation to output rate given in Figure 15 for seasons of 100, 300, and 500 hours' operation, where these graphic results are also summarized in the form of equations relating total cost to rate of output and method used for seasons of specified length.

Comparisons of cost with different methods of lidding the standard crate, as given in Figure 15, indicate that with short season operation, method A--hand lidding--is lowest in cost over a considerable range in plant size. With a season of 300 hours, however, method A is lowest in cost below plant capacities of 120 crates per hour, method C--standard lidding--from 120 to 420 crates per hour, and method D--high-speed lidding--for plant capacities above 420 crates per hour. With a 500-hour season, method A is lowest in cost with plant capacities below about 80 crates per hour, method C from 80 to 260 crates per hour, and method D for capacities greater than 260 crates per hour.

Carloading

Loading crates and cartons involves stacking the containers in rail cars or motor trucks and preparing the load for shipment. Since most of the standard

TABLE 16

Packed Container-Closing Crew and Equipment Requirements and Costs in Relation to Methods Used and Capacity Rate of Plant Output. Packing California Plums, 1955

		Variable costs per hour			Fixed costs		
Plant capacity	Workers[a]	Labor[b]	Equipment repair and power[c]	Total	Equipment replacement cost[d]	Average annual fixed cost[e]	Equations of annual fixed cost and variable cost per hour[f]
containers per hour	number	dollars					
	Method A--hand lidding, crates						
95	1	1.05	.01	1.06	120	14	Annual fixed cost = 7 + 15P Variable cost per hour = .50 + 1.11P
190	2	2.10	.01	2.11	240	28	
285	3	3.15	.02	3.17	360	41	
380	4	4.20	.02	4.22	480	55	
475	5	5.25	.03	5.28	600	69	
570	6	6.30	.04	6.34	720	83	
665	7	7.35	.04	7.39	840	97	
760	8	8.40	.05	8.45	960	110	
855	9	9.45	.05	9.50	1,080	124	
950	10	10.50	.06	10.56	1,200	138	
1,045	11	11.55	.07	11.62	1,320	152	
	Method B--stitcher lidding, crates						
330	1	1.30	.12	1.42	1,850	244	Annual fixed cost = 122 + 74P Variable cost per hour = .71 + .43P
660	2	2.60	.24	2.84	3,700	488	
990	3	3.90	.36	4.26	5,550	732	
1,320	4	5.20	.48	5.68	7,400	976	
	Method C--standard lidding, crates						
460	1	1.30	.14	1.44	2,350	310	Annual fixed cost = 155 + 67P Variable cost per hour = .72 + .31P
920	2	2.60	.28	2.88	4,700	620	
1,380	3	3.90	.42	4.32	7,050	930	
	Method D--high-speed lidding, crates						
750	1	1.30	.23	1.53	4,000	528	Annual fixed cost = 264 + 70P Variable cost per hour = .77 + .20P
1,500	2	2.60	.46	3.06	8,000	1,056	
	Method E--carton closing						
205	1	1.05	--[g]	1.05	--	--	Annual fixed cost = 0 Variable cost per hour = .53 + .51V
410	2	2.10	--	2.10	--	--	
615	3	3.15	--	3.15	--	--	
820	4	4.20	--	4.20	--	--	
1,025	5	5.25	--	5.25	--	--	

[a] Container closing standards (containers per hour): Method A--95; Method B--330; Method C--460; Method D--750; and Method E--205.

[b] Based on a wage rate of $1.05 per hour for Method A and E and $1.30 per hour for the other methods. This includes an allowance of approximately 5 per cent for employer's contributions to Social Security and Workmen's Compensation Insurance.

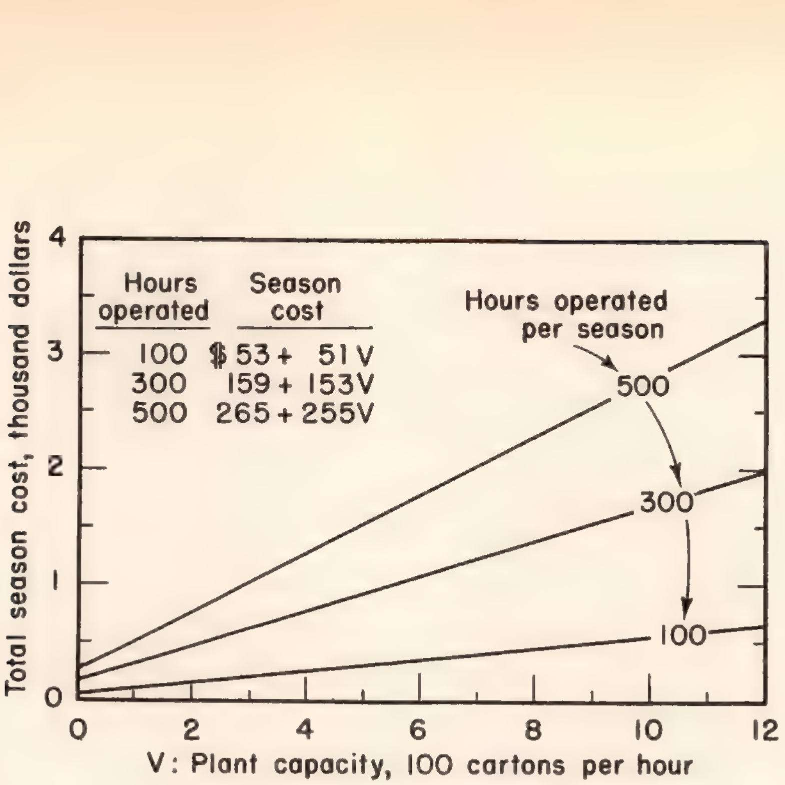
[c] Equipment variable repair estimated at 0.5 per cent of replacement cost per 100 hours of use and power at $0.03 per hour per motor horsepower.

[d] Equipment replacement costs: Hand press lidder--$120; stitcher lidder--$1,850; standard lidder--$2,350; and high-speed lidder--$4,000. One equipment unit is required per operator.

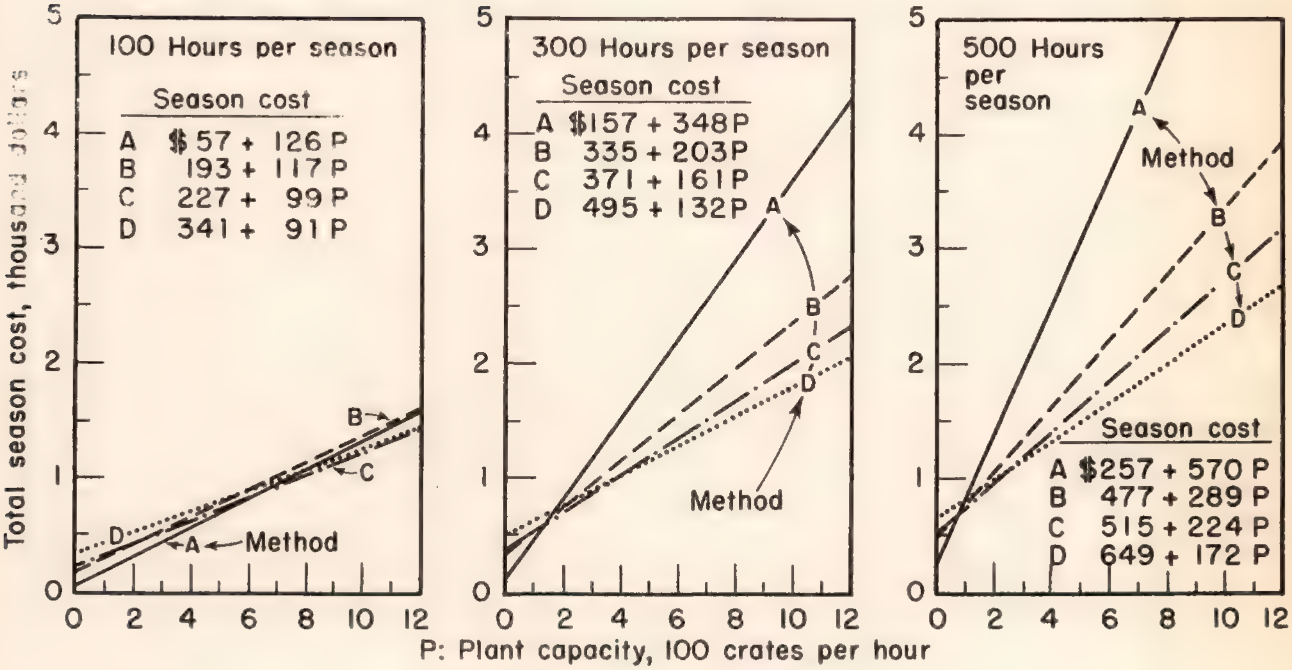
[e] Estimated at 11.5 per cent of replacement cost for Method A and 13.2 per cent for the other methods. See Appendix Table C for the basis and details of this charge.

[f] P = plant capacity in 100 crates per hour and V = plant capacity in 100 cartons per hour.

[g] Dashes indicate no equipment used with this method.



A. CARTONS



B. CRATES

Figure 15. Total Season Cost Of Closing Packed Containers In Relation To Capacity Plant Output Rate And Length Of Operating Season.

crates are shipped by rail, costs are presented only with respect to carloading.[1] With either type of container, the carloading job includes preliminary work such as moving the car to the loading dock, placing the carloading ramp, and stacking the containers. In loading crates, the work also includes placing light frame gates between successive rows of containers to hold the crates in place and maintain ventilation channels as well as bracing the center of the load to prevent shifting en route.[2] The loading method considered for cartons presumes the use of a solid load with minimum requirements as to bracing.[3]

Estimating data of the type applied in preceding sections are presented in Table 17 for the carloading operations. The equations for estimating variable costs per hour, including materials costs, and annual fixed charge for equipment are used to develop season cost relationships given in Figure 16. The chart shows loading costs with cartons to be substantially lower than with crates. This is due in part to lower labor requirements with the cartons, but the major saving consists of reduced costs of bracing materials.

Miscellaneous Equipment, Power Wiring, and Field Lugs

Miscellaneous items such as office equipment, platform scales, miscellaneous tools and fixtures, and power wiring for equipment are represented in this cost component. Estimated investment costs for such items in relation to selected plant sizes are given in Table 18 and are used to develop the relation of investment cost and annual fixed charge to plant output rate shown (graphically and in equation form) in Figure 17.

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[1] Truck-loading costs for a given size load ordinarily will be less than carloading. This is because gate bracing and other spacing materials used in carloading are not required in truck loads. Also, loading labor requirements due to the omission of bracing are less with trucks than cars.

[2] Methods other than gates to maintain crate-spacing--for example, lath strips nailed horizontally along each row of crates--were observed. The gate system, however, was the most widely used and is the only procedure considered here.

[3] The solid load requires either that the fruit be precooled or that the self-locking type of carton cover be used, which preserves spacing between adjacent cartons essential to fruit cooling. Several different load types other than the one described above have been studied experimentally. See Pilz, et. al., op. cit., pp. 28-31.

TABLE 17

Crew and Equipment Requirements and Costs of Loading Containers of Packed Fruit in Rail Cars Related to Capacity Rate of Loading. Packing California Plums, 1955

Plant capacity	Number of car-loaders[a]	Variable costs per hour				Fixed costs		Equations of annual fixed cost and variable cost per hour[g]
		Labor[b]	Equipment repair[c]	Gate and bracing material[d]	Total	Equipment replacement cost[e]	Average annual fixed cost[f]	
containers per hour	dollars							
	Crate							
205	1	1.15	.05	5.62	6.82	900	119	Annual fixed cost = 115 + 2P Variable cost per hour = .63 + 3.30P
410	2	2.30	.05	11.23	13.58	900	119	
615	3	3.45	.05	16.85	20.35	960	127	
820	4	4.60	.05	22.46	27.11	960	127	
1,025	5	5.75	.05	28.09	33.89	1,020	135	
1,230	6	6.90	.05	33.70	40.65	1,020	135	
	Carton--solid load							
380	1	1.15	.05	.39	1.59	900	119	Annual fixed cost = 115 + 1V Variable cost per hour = .63 + .41V
760	2	2.30	.05	.78	3.13	900	119	
1,140	3	3.45	.05	1.17	4.67	960	127	
1,520	4	4.60	.05	1.56	6.21	960	127	

a/ Labor standards are 205 crates per hour or 380 cartons per hour.

b/ Based on a wage rate of $1.15 per hour which includes an allowance of approximately 5 per cent of worker's pay for employer's contributions to Social Security and Workmen's Compensation Insurance.

c/ Equipment variable repair estimated at 0.5 per cent of replacement cost per 100 hours of use.

d/ Gate and bracing material for the crate is estimated from accounting record data. For the carton no gates are required. The cost of car bracing with the carton is estimated on the basis of 20 lineal feet of 2" x 4" bracing material per car of 1,100 cartons. Bracing material price--$86 per 1,000 board feet.

e/ Equipment includes 1 car squeeze--$840; plus 1 loading ramp for every 2 carloaders--$60 each.

f/ Estimated at 13.2 per cent of replacement cost. See Appendix Table C for the basis and the details of this charge.

g/ P = plant capacity in 100 crates per hour, and V = plant capacity in 100 cartons per hour.

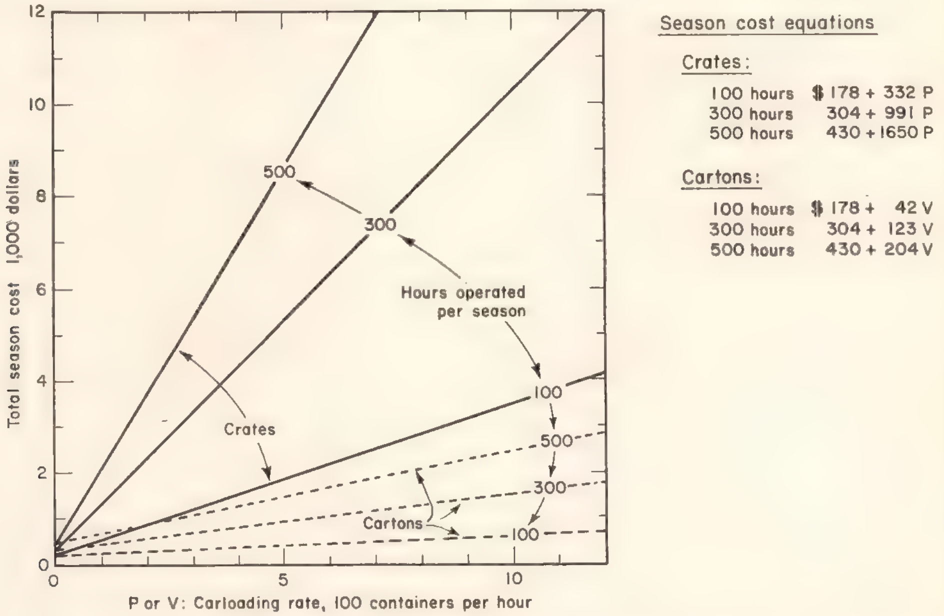

Figure 16. Total Season Cost of Carloading in Relation to Rate of Loading, Length of Operating Season, and Type of Container. Packing California Plums, 1955.

TABLE 18

Replacement Cost of Miscellaneous Tools, Equipment, and Power Wiring. Packing California Plums, 1955

Item[a]	Replacement cost				
	Field lugs run per hour				
	250	500	750	1,000	1,500
	dollars				
Miscellaneous tools and equipment					
Label stands	18	18	36	36	54
Clocks	24	24	24	48	48
Fire extinguisher	60	120	180	240	300
Power saw	400	400	400	400	400
Platform scale (1,000-2,500 pounds)[b]	400	400	840	840	840
Field lugs	10,000	20,000	30,000	40,000	60,000
Tools, miscellaneous	100	300	500	700	1,100
Power wiring	300	600	750	900	1,200
Office equipment					
Furniture and miscellaneous	675	1,280	1,490	1,620	1,890
Business machines	600	1,210	1,380	1,420	1,550
Vault	240	240	360	480	1,080
Total	12,817	24,592	35,960	46,684	68,462

[a] Unit costs of major items are: Power saw--$400, and field lugs--$0.80.

[b] One platform scale per plant.

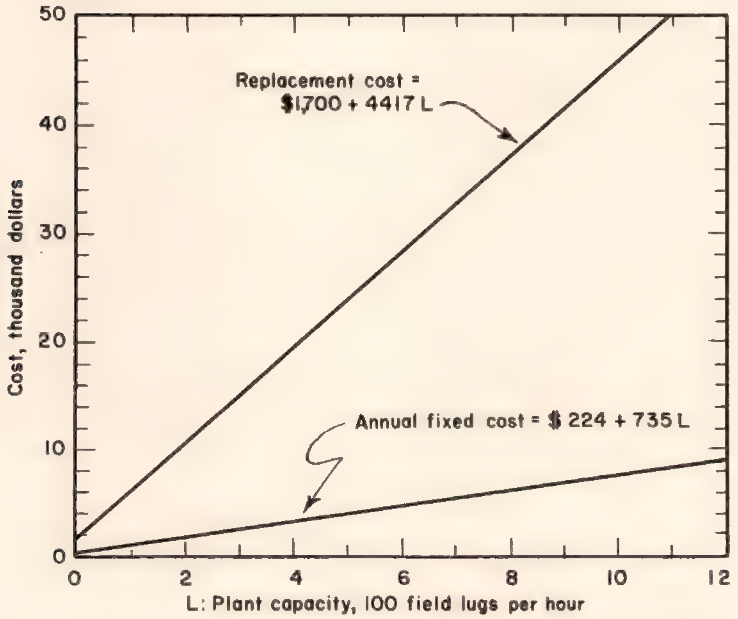

Figure 17. Replacement and Annual Fixed Cost of Miscellaneous Equipment, Power Wiring, and Field Lugs in Relation to Plant Capacity. Packing California Plums, 1955.

Direct Supervision and Miscellaneous Labor

In addition to direct labor accounted for in the preceding analyses of particular plant stages, there are several general categories of labor cost not chargeable to particular operations. These include: (1) direct supervision such as general and assistant foremen and foreladies; (2) night watchmen; (3) seasonal office clerks; and (4) miscellaneous and utility workers, such as those who supply pads and baskets to the packers and perform other miscellaneous jobs as required.

As in the preceding sections, labor costs are estimated in terms of a representative wage rate and the number of workers required in each labor category in plants of given size. Generally, the wage rates used are independent of plant size. Wages of plant foremen, however, tend to increase with size of plant, and this effect is reflected in the wage schedule for this category. For convenience, reimbursement of workers paid on a weekly or monthly basis was converted to an hourly rate, assuming an eight-hour day and six-day work week. Labor requirements are estimated separately for place-packing and bulk-filling operations, since less supervisory labor is required in the bulk-filling operation. Numbers of workers. wage data, and hourly plant costs for workers in this category are shown in relation to method of packaging and plant size in Table 19. These results are shown graphically in Figure 18.

Building Costs

Another category of general costs to be considered is that related to investment in the building. This cost varies with size of plant and type of construction used. The type of construction used in the analysis is typical of that found in plum packing plants in which hand-truck equipment is used for in-plant transportation.[1/] This consists of a wood-frame structure with a wood floor constructed at truck-bed height. Exterior walls are surfaced with a single layer of wood sheathing--except office spaces, which have an interior finish.

[1/] Investment costs only for hand-truck plants are considered here in view of earlier determination in analysis of costs of in-plant transportation that hand-truck equipment would prove more economical than fork trucks over the range of plant capacities and length of operating season encountered in California plum packing plants. If fork truck equipment were considered, a different type of construction ordinarily would be required, and somewhat different cost relationships would be encountered. See Sammet and I. F. Davis, Building and Equipment Costs, Apple and Pear Packing (Berkeley: University of California, College of Agriculture, Agricultural Experiment Station, December, 1952), 38p. (Giannini Foundation Mimeographed Report No. 141.)

TABLE 19

Direct Supervision and Miscellaneous Labor Requirements and Costs
Related to Plant Capacity in Crates Per Hour.
Packing California Plums, 1955

Plant capacity[b]	Job[a]																		Total cost per hour	Equation of variable cost per hour[f]
	Plant foreman		Assistant foreman		Forelady		Assistant forelady		Inspector[d]		Loading foreman		Miscellaneous		Night man		Seasonal office clerks[e]			
	Number	Wage rate[c]	Number	Wage rate[c]	Number	Wage rate[c]	Number	Wage rate[c]	Number	Wage rate[c]	Number	Wage rate[c]	Number	Wage rate[c]	Number	Wage rate[c]	Number	Wage rate[c]		
crates per hour																			dollars	
	Place packing																			
100	1	1.25	--[g]	--	--	--	--	--	--	--	--	--	1	1.05	--	--	--	--	2.30	Variable cost per hour = .40 + 2.04P
300	1	1.30	--	--	1	1.25	--	--	--	--	--	--	1	1.05	--	--	--	--	3.60	
500	1	1.60	--	--	1	1.25	2	1.25	--	--	--	--	1	1.05	1	1.05	1	1.20	8.65	
700	1	1.90	1	1.60	1	1.60	3	1.25	--	--	--	--	2	1.05	1	1.05	1	1.20	13.20	
900	1	2.20	1	1.60	1	1.60	5	1.25	--	--	1	1.30	2	1.05	1	1.05	2	1.20	18.50	
1,100	1	2.50	2	1.60	1	1.60	6	1.25	--	--	1	1.30	2	1.05	1	1.05	2	1.20	21.65	
1,300	1	2.80	2	1.60	1	1.60	8	1.25	--	--	1	1.30	3	1.05	2	1.05	3	1.20	27.75	
	Bulk filling																			
100	1	1.25	--	--	--	--	--	--	1	1.25	--	--	1	1.05	--	--	--	--	3.55	Variable cost per hour = .80 + 1.60P
300	1	1.30	--	--	--	--	--	--	1	1.25	--	--	1	1.05	--	--	--	--	3.60	
500	1	1.60	--	--	--	--	--	--	2	1.25	--	--	1	1.05	1	1.05	1	1.20	7.40	
700	1	1.90	1	1.60	--	--	--	--	3	1.25	--	--	2	1.05	1	1.05	1	1.20	11.60	
900	1	2.20	1	1.60	--	--	--	--	3	1.25	1	1.30	2	1.05	1	1.05	2	1.20	14.40	
1,100	1	2.50	2	1.60	--	--	--	--	4	1.25	1	1.30	2	1.05	1	1.05	2	1.20	17.55	
1,300	1	2.80	2	1.60	--	--	--	--	5	1.25	1	1.30	3	1.05	2	1.05	3	1.20	22.40	

[a] Wage rates for jobs paid on a daily, weekly, or monthly basis were converted to an hourly rate on the basis of an eight-hour day, six-day week. All wage rates include an allowance of approximately 5 per cent of worker's pay for employer's contributions to Social Security and Workmen's Compensation Insurance.

[b] For brevity, crew requirements and costs are given at plant capacity intervals of 200 crates per hour, although estimates also were made at intervals of 100 crates per hour for use in deriving the variable cost equations.

[c] Dollars per hour.

[d] Machine attendance is performed by one of the inspectors as needed.

[e] Does not include permanent bookkeepers and accountants.

[f] P = plant capacity in 100 crates per hour.

[g] Dashes indicate the job is not required for this method of packaging or plant capacity.

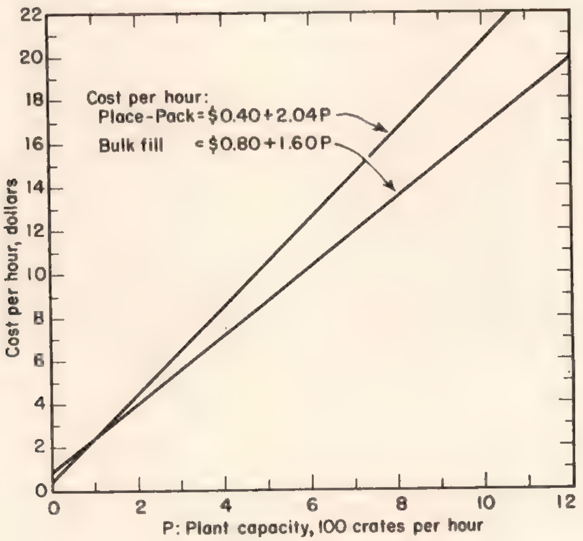

Figure 18. Direct Supervision and Miscellaneous Labor Costs in Relation to Method of Packaging and Plant Capacity in Crates Per Hour. Packing California Plums, 1955.

The clear height from the floor to the underside of the roof trusses is 12 feet. Roof spans are relatively short--30 to 40 feet. All spaces are roofed except the area for storage of empty lugs, which consists of an open platform.

To estimate investment costs for buildings such as the above, floor space requirements in plants of selected capacity rate were determined on the basis of space required for equipment, traffic aisles, and storage in well-organized plants. Replacement costs per square foot of building areas were then applied to the estimated space requirements to obtain an estimate of building cost in relation to plant capacity. The unit building cost data were obtained from previously published information based on engineering estimates of the construction cost of buildings of specified size and type.1/ The earlier estimates were adjusted to the 1955 price level by means of a construction cost index. Results of these computations with respect to plants of selected capacity output rate are given in Table 20. Both Table 20 and Figure 19 express investment costs in terms of an estimated annual charge in relation to plant capacity rate.

Administrative Costs and General Operating Expense

Administrative costs are defined as consisting of the salaries of plant managers, field men, and permanent office employees such as bookkeepers and accountants. General operating expense includes legal and accounting expenses not covered in the administrative expense category, travel expense, liability, inventory or other insurance costs not included in particular stages, and other similar general costs. Data for estimating these costs were obtained from accounting records of pear, apple, grape and plum packing houses, in which there is a high degree of similarity in plant operation and office procedure. Data from individual plants were related to plant output rate which, for the purposes of this report is expressed as field lugs run per hour. The average relationship of administrative cost and general operating expense to field lugs run per hour is shown graphically and in equation form in Figure 20.2/

1/ Ibid., p. 15. The investment costs used include outlays for paving and a railroad siding.

2/ Considerable variability was observed among plants in the level of cost in these categories. This was partly attributable to variation in accounting classification and to differences in administrative and general expense activities in different firms, as well as to differences in plant capacity. It also is likely that such expenses are jointly related to length of season and plant capacity, but introduction of operating time per season did not improve the correlation and so the simpler form relating costs in these catefories to rate of plant output was used. The above results were derived from material in Sammet, "Economic and Engineering Factors . . .," p. 344.

TABLE 20

Building Space Requirements and Investment Costs (Excluding the Packaging Area) in Relation to Capacity Output Rate in Plant of Hand-Truck Type Construction. Packing California Plums, 1955

Plant capacity	Roofed area requirements[a]			Average cost per square foot[b]	Building costs, excluding the packaging area		
	Belt packing area	Other plant area	Total		Replacement	Annual fixed cost[c]	Equation of annual fixed cost[d]
crates per hour	square feet			dollars			
100	1,050	5,070	6,120	3.05	15,463	1,624	Annual fixed cost = 1,220 + 388P
300	2,155	9,415	11,570	2.40	22,596	2,373	
500	3,260	13,755	17,015	2.20	30,261	3,177	
700	4,365	18,095	22,460	2.05	37,095	3,895	
900	5,470	22,440	27,910	2.00	44,880	4,712	
1,100	6,570	26,780	33,350	1.95	52,221	5,483	
1,300	7,675	31,125	38,800	1.90	59,138	6,209	
1,500	8,780	35,465	44,245	1.90	67,384	7,075	

[a] Building area required was determined from studies in the plants. The packaging area is estimated by the equation: Area in square feet = 500 + 550P, where P = 100 crates per hour plant capacity. The other plant area was estimated by the equation: Area in square feet = 2,900 + 2,171P.

[b] The average cost per square foot of building area is based on the equation: Building replacement cost = \$8,503 + \$1.684A, where A = the roofed area in square feet. The average costs per square foot are based on a belt packing plant but would differ only slightly with other types of packaging. Based on building replacement cost information in Sammet, L. L., and I. F. Davis, Building and Equipment Costs, Apple and Pear Packing (Berkeley: University of California, College of Agriculture, Agricultural Experiment Station, December, 1952), p. 15. (Giannini Foundation Mimeographed Report No. 141.) Processed. (The fifth report in a series on Efficiency in Fruit Marketing.) Adjusted to the 1955 price level.

[c] Based on an annual charge of 10.5 per cent of replacement cost. See Appendix Table C for the details and basis of this charge.

[d] P = plant capacity in 100 crates per hour.

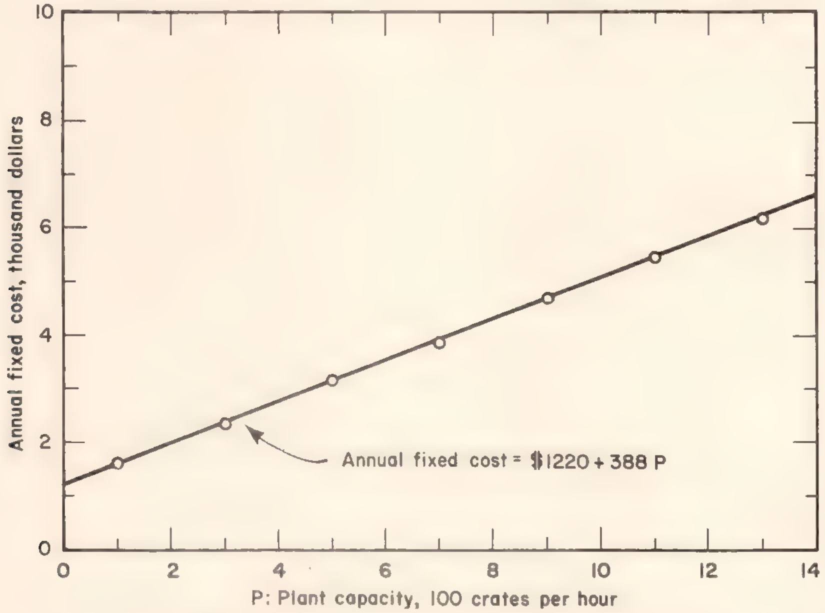

Figure 19. Building Annual Fixed Costs--Excluding the Packaging Area--in Relation to Plant Capacity in Crates Per Hour. Packing California Fresh Plums, 1955.

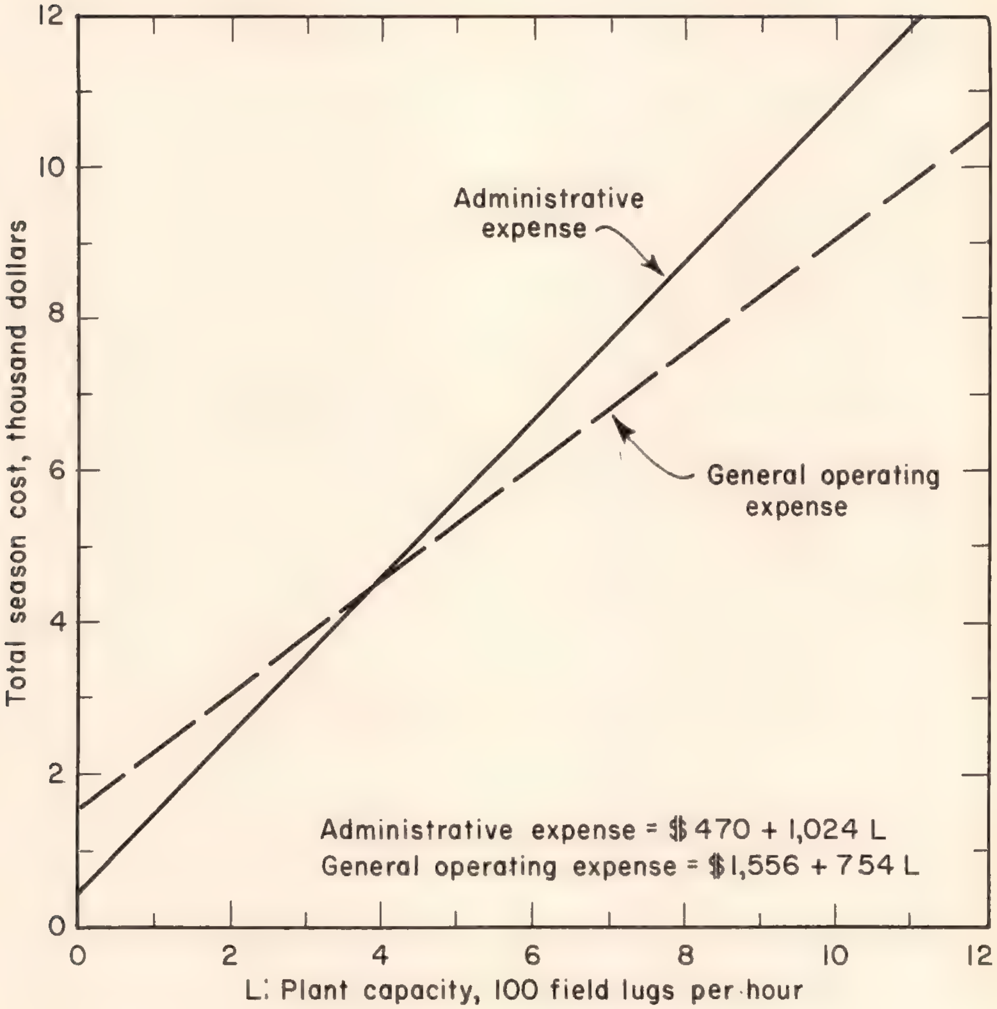

Figure 20. **Administrative and General Operating Expenses Per Season in Relation to Plant Capacity in Field Lugs Per Hour. Packing Fresh California Plums, 1955.**

TOTAL PLANT COST

The preceding analyses concerning the various categories of operating stages and general costs provide the material for estimating total plant costs. This involves selection of the low-cost technique in each stage and the aggregation of their costs into totals for the entire plant operation. When the stages and cost components are defined so as to be independent in terms of costs--as in this study--this requires only a simple summation of cost relationships developed in each stage analysis. Since relative costs with different methods have been shown to depend on both rate of output and length of operating season, these factors must be considered in the selection of low-cost technique. The details and results of this procedure are given below.

Simplifications and Specifications

To simplify and make explicit the development of total plant cost relationships, certain conditions are assumed. While in some respects these represent departures from operating conditions actually encountered--particularly in given plants--they are not sufficiently drastic to prevent the development of realistic cost comparisons. The conditions specified are as follows:

1. Initially total plant costs are estimated exclusive of container materials costs. Data concerning the effect of materials costs with different types of container are presented later.
2. The analysis assumes operation in a given plant to be at constant output rate for an entire season.
3. The development of total plant cost relationships involves selection of the least-cost method in all but the packaging stage. With regard to packaging, complete analyses of plant cost are made for each of three different methods so as to demonstrate the effect of packaging method on plant costs.
4. Shipment of all packed fruit to out-of-state markets in railroad cars is assumed. Costs of packing for local shipment or for movement in highway trucks are not considered.
5. Plant costs in packing fruit in fiberboard cartons are developed in relation to volume of output expressed in crate equivalents.
6. Since the price of land occupied by the packing house varies widely with location, it has been omitted from the analysis. The range in

site costs likely to be encountered would not, however, have an important effect on the selection of low-cost method in individual plant stages or on total plant cost.

Combining Stage and Component Costs

To facilitate selection of the least-cost method and the related cost equation in each stage, all the cost equations developed in stage and cost component analyses are assembled in Table 21. For convenience in the process of combining the cost equations, these have been converted to a crate-equivalent basis.[1] The data given in Table 21 relate to 20 per cent culls; similar data in regard to culling rates of 10 and 40 per cent are given in Appendix Table E.

The selection procedure as applied to a given plant stage may be illustrated by reference to Figure 15, page 60, which shows graphically total season costs with four different methods of lidding the standard crate. The charts indicate that with 100 hours' operation per season method A is lowest in cost in the output range up to about 700 crates per hour and that in the range of 700 to 1,400 crates per hour, method C is lowest in cost. With 300 hours' operation, the low-cost methods prove to be method A in the output range up to about 120 crates per hour, method C in the range from 120 to about 400 crates per hour, and method D for output rates exceeding 400 crates per hour. Similar results--but with differences in the applicable rate range with each method--are indicated in the chart relating to 500 hours' operation per season and can be developed for still other lengths of operating season.

By means similar to the above the low-cost method in each stage can be determined with respect to plant output rate and hours of operation per season. The results of such comparisons of cost equations pertaining to a culling rate of 20 per cent are summarized in Table 22, which indicates with respect to seasons of 100, 300, and 500 hours' operation the methods selected in each stage and the range in output rate over which the selected method is applicable.

Using the results in Table 22 as a guide, equations of total season cost for each stage selected from Table 21 may be associated with the output range over

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[1] Equations originally developed with field lugs as the volume variable are adjusted by multiplying the cost coefficient of that variable by 0.972. Equations developed with cartons as the volume variable are adjusted to a crate equivalent basis by multiplying the cost coefficient of that variable by 1.12.

TABLE 21

Equations Relating Annual Fixed Cost, Variable Cost Per Hour, and Total Season Cost to Crate Equivalent Output Rate for All Methods of Operation in Each Plant Stage and Cost Component, 20 Per Cent Culls. Packing California Plums, 1955a/

Stage or cost component and methods	Type of containers packed	Stage or component cost equations b/				
		Annual fixed cost	Variable cost per hour	Total season cost		
				100 hours	300 hours	500 hours
		dollars				
Plant transportation						
Hand truck						
A--Hand truck, all jobs	crate	6 + 11P	2.20 + 1.26P	226 + 137P	666 + 390P	1,106 + 643P
	carton	6 + 12P	2.35 + 1.31P	241 + 143P	711 + 405P	1,181 + 668P
B--Conveyor for packed fruit	c/	110 + 42P	2.20 + .89P	330 + 131P	770 + 310P	1,210 + 489P
C--Mechanical cull handling	crate	315 + 53P	1.50 + 1.07P	465 + 160P	765 + 374P	1,065 + 588P
	carton	325 + 48P	1.55 + 1.14P	480 + 161P	790 + 389P	1,100 + 616P
D--Conveyors for packed fruit and culls	c/	445 + 81P	1.55 + .70P	600 + 151P	910 + 291P	1,220 + 431P
Fork truck						
A--Fork truck, all jobs	crate	420 + 224P	2.25 + .86P	645 + 309P	1,095 + 480P	1,545 + 651P
	carton	420 + 256P	2.30 + .87P	650 + 343P	1,110 + 518P	1,570 + 693P
B--Conveyor for packed fruit	c/	550 + 194P	2.20 + .63P	770 + 258P	1,210 + 384P	1,650 + 510P
C--Mechanical cull handling	crate	760 + 232P	1.80 + .64P	940 + 297P	1,300 + 425P	1,660 + 553P
	carton	770 + 255P	1.75 + .70P	945 + 325P	1,295 + 465P	1,627 + 605P
D--Conveyors for packed fruit and culls	c/	970 + 194P	1.75 + .46P	1,145 + 240P	1,495 + 332P	1,845 + 423P
Grading	c/	180 + 86P	1.70 + 1.51P	350 + 236P	690 + 538P	1,030 + 839P
Dumping						
A--Hand dumping	c/	3 + 2P	.53 + .29P	56 + 31P	162 + 89P	268 + 146P
B--Hand dumping with conveyor aids	c/	80 + 33P	1.80 + .63P	260 + 96P	620 + 223P	980 + 349P
C--Single-lug machine dumper	c/	185 + 60P	1.35 + .40P	320 + 100P	590 + 180P	860 + 260P
D--Stack dumper	c/	275 + 89P	.75 + .20P	350 + 110P	500 + 151P	650 + 192P
Packaging						
A--Place packing, belt equipment	crate	615 + 415P	.15 + 12.70P	630 + 1,685P	660 + 4,225P	690 + 6,765P
B--Place packing, belt equipment	carton	615 + 365P	.15 + 11.10P	630 + 1,475P	660 + 3,695P	690 + 5,915P
C--Place packing, bin equipment	crate	430 + 350P	.50 + 13.55P	480 + 1,705P	580 + 4,415P	680 + 7,125P
D--Place packing, bin equipment	carton	430 + 290P	.50 + 11.20P	480 + 1,410P	580 + 3,650P	680 + 5,890P
E--Bulk fill with rope sizing and bins	c/	340 + 125P	.60 + 1.41P	400 + 266P	520 + 548P	640 + 830P
F--Bulk fill with drop roll sizing and bins	c/	1,050 + 275P	1.10 + 1.43P	1,160 + 418P	1,380 + 704P	1,600 + 990P
G--Automatic filling	c/	2,150 + 580P	.78 + .21P	2,228 + 601P	2,384 + 643P	2,540 + 685P
Container making						
A--Manual nailing	crate	3 + 10P	0 + 2.41P	3 + 251P	3 + 732P	3 + 1,213P
B--Stitcher-type nailing machine	crate	122 + 98P	0 + 1.96P	122 + 294P	122 + 686P	122 + 1,078P
C--Standard nailing machine	crate	237 + 110P	0 + 1.77P	237 + 287P	237 + 641P	237 + 995P
D--End-feed nailing machine	crate	321 + 128P	0 + 1.66P	321 + 294P	321 + 626P	321 + 958P
E--Stapling carton	carton	35 + 28P	.63 + 1.79P	98 + 207P	224 + 566P	350 + 924P
F--Form full telescope carton manually	carton	2 + 7P	.53 + 2.31P	55 + 237P	161 + 699P	267 + 1,160P
Container supply						
A--Hand truck supply	crate	50 + 30P	1.40 + .33P	190 + 63P	470 + 129P	750 + 195P
	carton	39 + 20P	.53 + .38P	92 + 58P	198 + 134P	304 + 211P
B--Monorail conveyor	crate	185 + 32P	.68 + .23P	253 + 55P	389 + 101P	525 + 147P
	carton	188 + 34P	.65 + .20P	253 + 54P	383 + 94P	513 + 134P
C--Mezzanine supply	crate	60 + 40P	.56 + .29P	116 + 69P	228 + 127P	340 + 185P
	carton	53 + 28P	.57 + .27P	110 + 55P	224 + 109P	338 + 162P
D--Basement supply	crate	100 + 59P	1.37 + .32P	237 + 91P	511 + 155P	785 + 219P
E--Supply for bulk filling packages	c/	28 + 6P	1.25 + .29P	153 + 35P	403 + 93P	653 + 151P
Container closing						
A--Hand lidding	crate	7 + 15P	.50 + 1.11P	57 + 126P	157 + 348P	257 + 570P
B--Stitcher lidding	crate	122 + 74P	.71 + .43P	193 + 117P	335 + 203P	477 + 289P
C--Standard lidding	crate	155 + 67P	.72 + .31P	227 + 99P	371 + 161P	515 + 224P
D--High-speed lidding	crate	264 + 70P	.77 + .20P	341 + 91P	495 + 132P	649 + 172P
E--Hand closing	carton	d/	.53 + .57P	53 + 57P	159 + 171P	265 + 286P
Direct clerical	c/	3 + 1P	1.03 + .60P	106 + 62P	312 + 182P	518 + 302P
Carloading	crate	115 + 2P	.63 + 3.30P	178 + 332P	304 + 991P	430 + 1,650P
	carton	115 + 1P	.63 + .46P	178 + 47P	304 + 138P	430 + 228P
Miscellaneous equipment	c/	224 + 715P	d/	224 + 715P	224 + 715P	224 + 715P
Supervision						
A--Place-pack	c/	d/	.40 + 2.04P	40 + 204P	120 + 612P	200 + 1,020P
B--Bulk-fill	c/	d/	.80 + 1.60P	80 + 160P	240 + 480P	400 + 800P
Building costs	c/	1,220 + 388P	d/	1,220 + 388P	1,220 + 388P	1,220 + 388P
Administrative and general	c/	2,026 + 1,728P	d/	2,026 + 1,728P	2,026 + 1,728P	2,026 + 1,728P

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a/ Only stages in which the cost equations were related to field lugs per hour, L, in the analysis are affected by the culling rate. This includes the following stages: Plant transportation, grading, dumping, miscellaneous equipment, and administrative and general.

b/ Costs related to L--100 field lugs per hour--and costs related to V--100 cartons per hour--in the stage analyses were converted to costs related to P--100 crates per hour--in this table by multiplying the cost coefficient of L by .9722 and the cost coefficient of V by 1.12.

c/ No difference with respect to type of packed fruit container.

d/ Not applicable with this method or stage.

TABLE 22

Least-Cost Stage Technique and Applicable Range in Output Rate in Seasons of 100, 300, and 500 Hours Operation, With 20 Per Cent Culls. Packing California Plums, 1955

Stage and least-cost technique	Applicable output rate range in relation to hours per season		
	100 hours	300 hours	500 hours
	crate equivalents per hour		
Plant transportation			
Crate			
A--Hand truck	All rates	0 to 130	
B--Hand truck		130 to 720	
C--Hand truck			0 to 100
D--Hand truck		Over 720	Over 100
Carton			
A--Hand truck	0 to 760	0 to 60	
B--Hand truck	Over 760	60 to 720	
C--Hand truck			
D--Hand truck		Over 720	All rates
Dumping			
A	All rates	All rates	All rates
B			
C			
D			
Place-pack			
Crate			
A	Over 750	Over 50	All rates
C	0 to 750	0 to 50	
Carton			
B			
D	All rates	All rates	All rates
Bulk-fill			
E	All rates	All rates	[a]
F			
G			[a]
Container making			
Crate			
A	All rates	0 to 260	0 to 90
B			
C		260 to 570	90 to 230
D		Over 570	Over 230
Carton			
E	Over 140	Over 45	Over 20
F	0 to 140	0 to 45	0 to 20
Container supply			
Crate			
A			
B	Over 9.8	Over 6.2	Over 4.8
C	0 to 9.8	0 to 6.2	0 to 4.8
D			
Carton			
A	0 to 535	0 to 100	0 to 70
B		Over 1,090	Over 625
C	Over 535	100 to 1,090	70 to 625
Container closing			
Crate			
A	0 to 630	0 to 120	0 to 80
B			
C	Over 630	120 to 420	80 to 260
D		Over 420	Over 260

[a] Method E gives lowest cost with rates of output from 0 to 530 and 750 to 1,200 crate equivalents per hour. Method G gives lowest cost from 530 to 750 and over 1,200 crate equivalents per hour.

which they represent the least-cost method. For illustration, the results of such selection for plants operating 300 hours per season are given in Table 23, in regard to three different packaging methods--place-packing in crates and cartons and bulk-fill in either wooden crates or cartons. The table shows that in place-packing the standard crate, the total-cost equation for hand truck transportation method A is applicable for plants in the capacity range up to 130 crates per hour, while method B applies in the range of 130 to 720 crates per hour, and method D in the rate range exceeding 720 crates per hour. Similar developments can be traced in regard to other plant stages and other methods of packaging.

An equation for total plant cost in a 300-hour operating season can be obtained simply by summing within specified ranges in output rate the stage cost equations shown in Table 23.[1] Thus the table indicates that in place-packing the standard crate in a 300-hour season total plant cost in relation to output rate is \$6,772 + \$11,065(P) in the output range up to 130 crates per hour, while in the output range of 130 to 260 crates per hour the equation is \$7,090 + \$10,798(P) and so on for still higher rates of output. Similar results are given in regard to place-packing the carton and the use of bulk-fill methods with either type of container. These are shown graphically in Figure 21 for the three methods of packaging considered.

The cost lines shown in Figure 21 with a given packaging method reflect the tendency indicated in Table 23 toward a slightly decreasing slope--and an increasing fixed-cost component--as plant capacity increases. For the circumstances represented in Figure 21, however, this effect is quite small and a good approximation to the relation between total season cost and plant capacity will be given by a straight line representing "average" relationships for the various cost-curve segments. A simple approximation to this average relationship was established by accepting the cost equation applying to an output rate of 500 crates per hour as appropriate for the entire range in plant output rates considered.[2] Similar relationships were found in the development of total plant costs for other lengths of season and culling rates and equations of total plant cost based on them are summarized in Table 24.

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[1] The stage and total cost equations are of the form, Total season cost = a + b(P), in which "P" represents plant output rate in 100 crate equivalents per hour.

[2] This simplification results in slight overestimation of costs with low and high plant capacities. Computational determination of the amounts will, however, demonstrate the degree of overestimation to be quite small.

[illegible]

[illegible] Table 21.— [illegible]

[illegible]

1/ [illegible]

[illegible]

TABLE 23

Applicable Range in Output Rate for Equations Relating Total Season Cost to Plant Capacity in a 300-Hour Season, With 20 Per Cent Culls and Three Different Packaging Methods. Packing California Plums, 1955

Packing method and stage	Method selected	Total season cost equations and applicable ranges in output rate[a]					
		P = 0 to 1.2	P = 1.2 to 2.6	P = 2.6 to 4.2	P = 4.2 to 5.7	P = 5.7 to 7.2	P = over 7.2
		dollars					
PLACE-PACK CRATE							
Plant transportation	A	666 + 390P					
	B		770 + 310P	770 + 310P	770 + 310P	770 + 301P	
	D						910 + 291P
Dumping	A	162 + 89P	162 + 89P	162 + 89P	162 + 89P	162 + 89P	162 + 89P
Grading	b/	690 + 538P	690 + 538P	690 + 538P	690 + 538P	690 + 538P	690 + 538P
Packaging	A	660 + 4,225P	660 + 4,225P	660 + 4,225P	660 + 4,225P	660 + 4,225P	660 + 4,225P
Container making	A	3 + 732P	3 + 732P				
	C			237 + 641P	237 + 641P		
	D					321 + 626P	321 + 626P
Container supply	B					389 + 101P	389 + 101P
	C	228 + 127P	228 + 127P	228 + 127P	228 + 127P		
Direct clerical	b/	312 + 182P	312 + 182P	312 + 182P	312 + 182P	312 + 182P	312 + 182P
Container closing	A	157 + 348P					
	C		371 + 161P	371 + 161P			
	D				495 + 132P	495 + 132P	495 + 132P
Carloading	b/	304 + 991P	304 + 991P	304 + 991P	304 + 991P	304 + 991P	304 + 991P
Miscellaneous equipment	b/	224 + 715P	224 + 715P	224 + 715P	224 + 715P	224 + 715P	224 + 715P
Supervision	b/	120 + 612P	120 + 612P	120 + 612P	120 + 612P	120 + 612P	120 + 612P
Building costs	b/	1,220 + 388P	1,220 + 388P	1,220 + 388P	1,220 + 398P	1,220 + 388P	1,220 + 388P
Administrative; general	b/	2,026 + 1,728P	2,026 + 1,728P	2,026 + 1,728P	2,026 + 1,728P	2,026 + 1,728P	2,026 + 1,728P
TOTAL		6,772 + 11,065P	7,090 + 10,798P	7,324 + 10,707P	7,448 + 10,678P	7,693 + 10,637P	7,833 + 10,618P
		P = 0 to .6	P = .6 to 1.0	P = 1.0 to 7.2	P = 7.2 to 10.9	P = over 10.9	
		dollars					
PLACE-PACK CARTON							
Plant transportation	A	711 + 405P					
	B		770 + 310P	770 + 310P			
	D				910 + 291P	910 + 291P	
Dumping	A	162 + 89P	162 + 89P	162 + 89P	162 + 89P	162 + 89P	
Grading	b/	690 + 538P	690 + 538P	690 + 538P	690 + 538P	690 + 538P	
Packaging	D	580 + 3,650P	580 + 3,650P	580 + 3,650P	580 + 3,650P	580 + 3,650P	
Container making	E	224 + 566P	224 + 566P	224 + 566P	224 + 566P	224 + 566P	
Container supply	A	198 + 134P	198 + 134P				
	B					383 + 94P	
	C			224 + 109P	224 + 109P		
Direct clerical	b/	312 + 182P	312 + 182P	312 + 182P	312 + 182P	312 + 182P	
Container closing	E	159 + 171P	159 + 171P	159 + 171P	159 + 171P	159 + 171P	
Carloading	b/	304 + 138P	304 + 138P	304 + 138P	304 + 138P	304 + 138P	
Miscellaneous equipment	b/	224 + 715P	224 + 715P	224 + 715P	224 + 715P	224 + 715P	
Supervision	b/	120 + 612P	120 + 612P	120 + 612P	120 + 612P	120 + 612P	
Building costs	b/	1,220 + 388P	1,220 + 388P	1,220 + 388P	1,220 + 388P	1,220 + 388P	
Administrative; general	b/	2,026 + 1,728P	2,026 + 1,728P	2,026 + 1,728P	2,026 + 1,728P	2,026 + 1,728P	
TOTAL		6,930 + 9,316P	6,989 + 9,221P	7,015 + 9,196P	7,155 + 9,177P	7,314 + 9,162P	
		P = 0 to .6	P = .6 to 7.2	P = over 7.2			
		dollars					
BULK-FILL CONTAINER							
Plant transportation	A	711 + 405P					
	B		770 + 310P				
	D			910 + 291P			
Dumping	A	162 + 89P	162 + 89P	162 + 89P			
Grading	b/	690 + 538P	690 + 538P	690 + 538P			
Packaging	E	520 + 548P	520 + 548P	520 + 548P			
Container making	E	224 + 566P	224 + 566P	224 + 566P			
Container supply	E	403 + 93P	403 + 93P	403 + 93P			
Direct clerical	b/	312 + 182P	312 + 182P	312 + 182P			
Container closing	E	159 + 171P	159 + 171P	159 + 171P			
Carloading	b/	304 + 138P	304 + 138P	304 + 138P			
Miscellaneous equipment	b/	224 + 715P	224 + 715P	224 + 715P			
Supervision	b/	240 + 480P	240 + 480P	240 + 480P			
Building costs	b/	1,220 + 388P	1,220 + 388P	1,220 + 388P			
Administrative; general	b/	2,026 + 1,728P	2,026 + 1,728P	2,026 + 1,728P			
TOTAL[c]		7,195 + 6,041P	7,254 + 5,946P	7,394 + 5,927P			

a/ P = 100 standard crate equivalents per hour. Costs related to field lugs--represented by L in the stage cost equations--or cartons per hour--represented by V--have been converted to a basis of 100 crate equivalents per hour by multiplying the coefficient of L by 0.972 and the coefficient of V by 1.12. The output rate ranges were converted from a basis of L to P and from V to P by multiplying by 1.029 and .893, respectively, for 20 per cent culls. To avoid very small output rate ranges, those in this table may not exactly coincide, for all stages, with those in Table 22.

b/ No variation in method.

c/ Excludes the cost of container materials.

TABLE 24

The Effect of Per Cent of Culls, Length of Operating Season, and Method of Packaging on "Average" Equations Relating Total Season Cost to Rate of Plant Output. Packing California Plums, 1955[a]

Per cent culls and hours per season	Place packing					
	Standard crate		Test carton		Bulk fill	
	a	bP	a	bP	a	bP
	dollars					
10 Per cent culls						
100 hours	5,102 +	5,600P	5,169 +	4,897P	5,190 +	3,685P
300 hours	7,538 +	10,187P	7,105 +	8,704P	7,344 +	5,455P
500 hours	9,306 +	14,748P	8,754 +	12,546P	9,229 +	7,255P
20 Per cent culls						
100 hours	5,082 +	5,984P	5,164 +	5,287P	5,185 +	4,075P
300 hours	7,448 +	10,678P	7,015 +	9,196P	7,254 +	5,946P
500 hours	9,321 +	15,261P	8,769 +	13,059P	9,244 +	7,768P
40 Per cent culls						
100 hours	5,097 +	7,113P	5,164 +	6,410P	5,185 +	5,198P
300 hours	7,648 +	12,012P	7,215 +	10,529P	7,454 +	7,280P
500 hours	9,381 +	16,816P	8,829 +	14,614P	9,304 +	9,323P

[a] Coefficients of equations of the form: Total season cost = a + bP, where P represents capacity-plant output rate in 100 packed-crate equivalents per hour and the "average" equation is that for the cost-curve segment occurring at an output rate of 500 crates per hour.

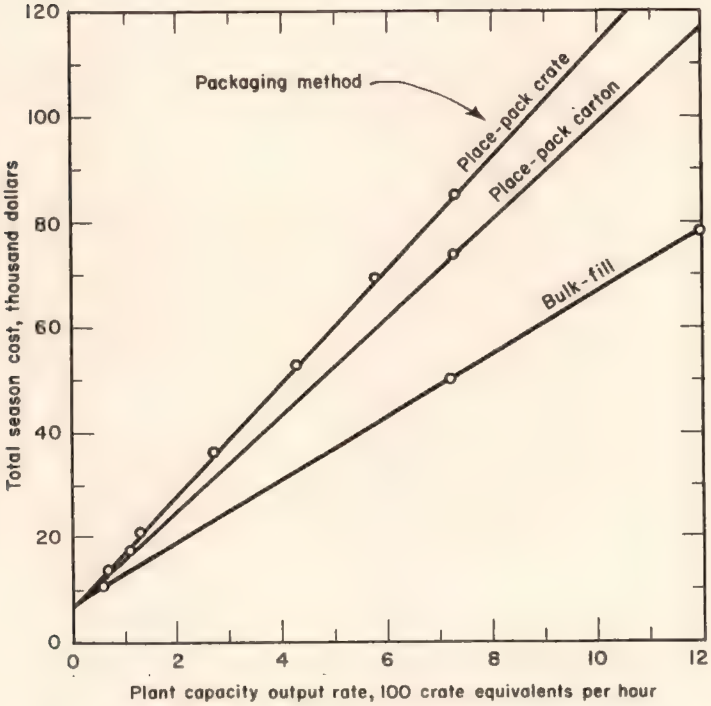

Figure 21. Total Season Cost in Relation to Capacity Output Rate and Method of Packaging When Given in Terms of Segments of Least-Cost Curves Applicable to Specified Output Ranges in a Season of 300 Hours Operation. California, 1955.

Effect of Plant Output Rate, Per Cent of Culls, and Length of Season on Total and Average Unit Cost

The equations in Table 24 provide a basis for indicating the extent to which changes in some plant operating conditions affect packing costs. These effects are not easily demonstrated if simultaneous variation in several important factors affecting costs are considered, but good indications of their nature are given if some factors are fixed at certain levels and others are allowed to vary. Some such effects are demonstrated in Figure 22, which shows total season and average costs in packing the standard crate (excluding the cost of container materials) in plants ranging in capacity output rate up to 1,200 crates per hour and operating in seasons of 100, 300, or 500 hours. These cost relationships are demonstrated in regard to culling rates of 10, 20, and 40 per cent.

The panel at the left in Figure 22 shows the increase in total season cost as plants of larger capacity are considered with given length of season and per cent of culls. Or, given a particular plant size, the difference in total plant costs is indicated as season lengths of 100, 300, or 500 hours are considered. With length of season given the curves show the differences in total average cost as the level of culling is fixed at 10, 20, or 40 per cent. These relationships are shown in terms of average unit cost in the right-hand panel of Figure 22. For example, unit costs with any of the operating conditions illustrated are shown to decrease as plants of larger size are considered. This reflects more effective use of individual labor and equipment units and--to a small degree--the use of more efficient methods as plant scale is increased. The rate of decline in unit cost is very rapid in the range of low output rates, but is relatively small in the range of high output rates. Thus with 300 hours operation per season and 20 per cent culls, unit costs with a plant capacity of 100 crates per hour are 60.4 cents per crate as compared with 41.8 cents per crate in plants of 400 crates per hour capacity--a decrease of 18.6 cents per crate. By contrast, unit costs in plants of 700 as compared with 1,000 crates per hour capacity are 39.1 cents and 38.1 cents per crate respectively--a decrease of only 1.0 cents per crate.

Figure 22 also shows a marked decline in average unit cost as hours per season in a plant of given capacity are increased. This reflects the effect of spreading the fixed costs of buildings and equipment and of administrative and overhead expense over a larger total volume as hours of plant operation at a given capacity rate are increased. With 20 per cent culls and a plant capacity of 500 crates per hour, for example, estimated unit costs with 100 hours' operation

[illegible]

[illegible] and opposite movements of 10%, 20%, or 30% [illegible] in respect to [illegible] 10%, 20%, and 30% [illegible]

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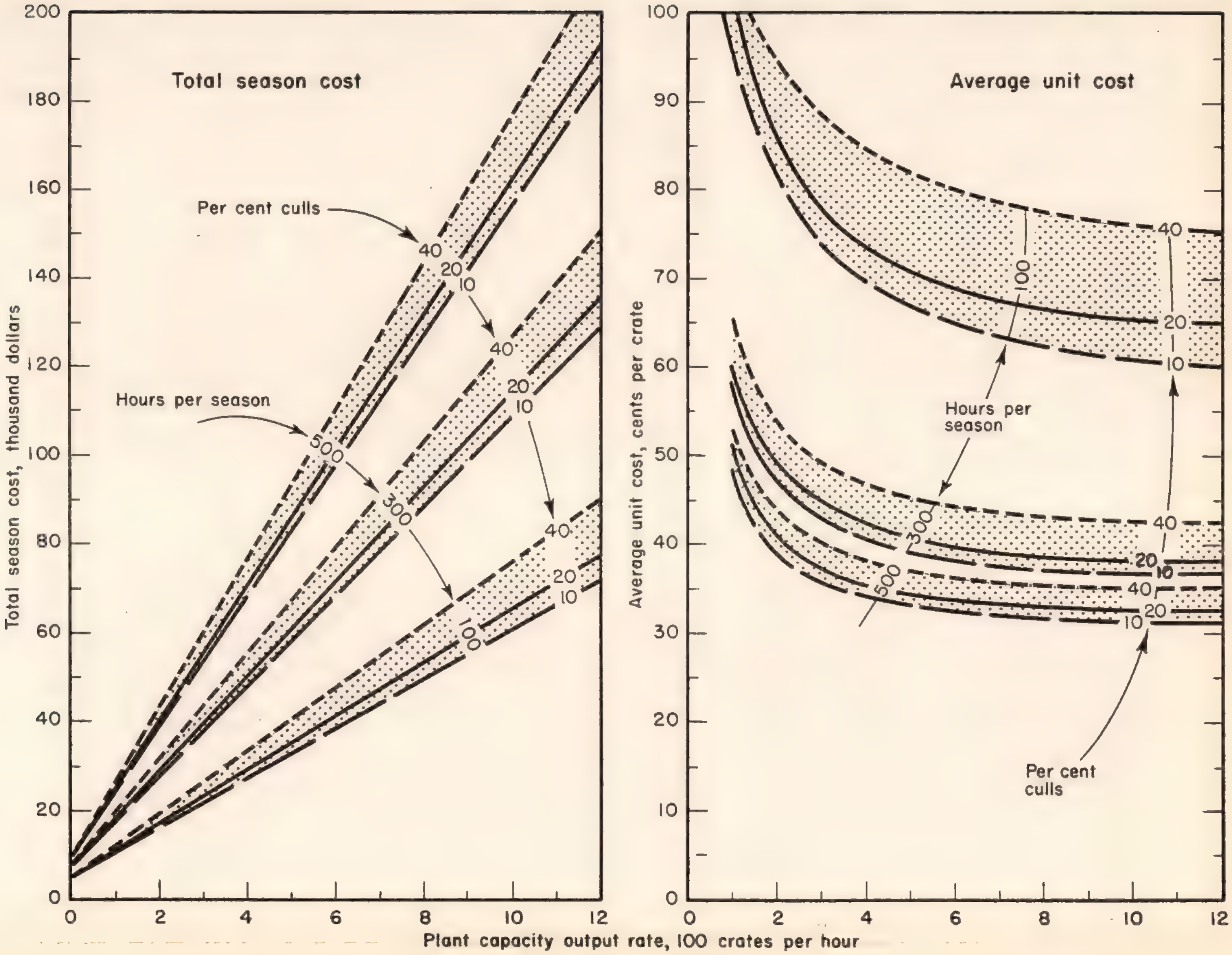

Figure 22. The Effect Of Output Rate, Hours Operated Per Season, And Per Cent Of Cull Fruit On Total Season And Average Unit Cost Of Packing Plums In The Standard Crate (Cost Of Container Not Included). California, 1955.

per season are 70.0 cents per crate as compared with 40.6 cents per crate with 300 hours operation and 34.3 cents per crate with 500 hours' operation. The rate of decrease indicated in these comparisons--and evident in the chart--becomes less as hours per season increase.

In addition to the above, Figure 22 shows that with given levels of output rate and hours of operation per season, relatively small increases in unit costs occur as culls rise from 10 to 20 per cent; a further doubling of the level of culling to 40 per cent, however, brings substantial increases in unit cost. This reflects the increased costs of handling, dumping, and grading larger quantities of field-run fruit for a given packed output as per cent of culls increase.

Effect of Operation at Less Than Plant Capacity

To this point, plant cost estimation has been based on the assumption of efficiently organized plants operated at capacity output rate. Operation of a given plant at rates less than capacity through a season of given length would be expected, of course, to result in higher unit costs. This follows in part from the fact that fixed costs--unchanged through undercapacity plant utilization--would be spread over a smaller total season output. In addition, variable costs for labor and other services--while subject to substantial reduction as output rate in a given plant is reduced below capacity--usually can only be reduced at a rate less than proportionate to the reduction in output rate. To illustrate this effect, calculations of variable cost were made for three plants with capacity rates of 100, 300, and 600 crates per hour. In the plants of 100 crates per hour capacity, for example, crew requirements and other variable inputs and their costs were estimated at a level consistent with operation at only 50 crates per hour. Similarly, costs in the plant of 300 crates per hour capacity were computed at the reduced levels of 100 and 200 crates per hour, while in the plant of 600 crates per hour capacity costs were estimated with reduced output rates of 100 and 300 crates per hour. The results of these calculations in a season of 300 hours' operation are summarized in Table 25 and are shown graphically in Figure 23. The solid cost-lines in both panels of Figure 23 represent the estimated level of costs in efficiently organized plants of different size when operated at their capacity output rates. The dashed lines represent the level of costs in plants of particular capacities when operated at reduced levels of output. Unit costs are shown to be substantially higher in underutilized plants in comparison with costs in plants designed for capacity operation at a given rate of output. This

TABLE 25

The Effect of Underutilization of Plant Capacity on Costs of Packing Fresh Plums in the Standard Crate in Plants of Three Different Sizes, 300-Hour Season, 20 Per Cent Culls. California, 1955

Packing method and stage	Plant capacity, 100 crates per hour				Plant capacity, 300 crates per hour					Plant capacity, 600 crates per hour				
	Method used	Annual fixed cost	Variable cost		Method used	Annual fixed cost	Variable cost			Method used	Annual fixed cost	Variable cost		
			Plant operating rate				Plant operating rate					Plant operating rate		
			50 crates per hour	100 crates per hour			100 crates per hour	200 crates per hour	300 crates per hour			100 crates per hour	300 crates per hour	600 crates per hour
		dollars per season				dollars per season					dollars per season			
Plant transportation	A	17	849	1,038	B	236	927	1,194	1,461	B	362	927	1,461	2,262
Dumping	A	5	203	246	A	9	246	333	420	A	15	246	420	681
Grading	[a]	266	737	963	[a]	438	963	1,416	1,869	[a]	696	963	1,869	3,228
Packaging	A	1,030	1,950	3,855	A	1,860	3,855	7,665	11,475	A	3,105	3,855	11,475	22,905
Container making	A	13	362	723	C	567	531	1,062	1,593	D	1,089	498	1,494	2,988
Container supply	C	100	212	255	C	180	255	342	429	C	300	255	429	690
Container closing	A	22	317	483	C	356	309	402	495	D	684	291	411	591
Direct clerical	[a]	4	399	489	[a]	6	489	669	849	[a]	9	489	849	1,389
Carloading	[a]	117	684	1,179	[a]	121	1,179	2,169	3,159	[a]	127	1,179	3,159	6,129
Supervision	[a]	--[b]	426	732	[a]	--	732	1,344	1,956	[a]	--	732	1,956	3,792
Miscellaneous equipment	[a]	939	--	--	[a]	2,369	--	--	--	[a]	4,514	--	--	--
Building costs	[a]	1,608	--	--	[a]	2,384	--	--	--	[a]	3,548	--	--	--
Administrative; general	[a]	3,754	--	--	[a]	7,210	--	--	--	[a]	12,394	--	--	--
TOTAL		7,875	6,139	9,963		15,736	9,486	16,596	23,706		26,843	9,435	23,523	44,655

[a] Only one method.

[b] Dashes indicate not applicable.

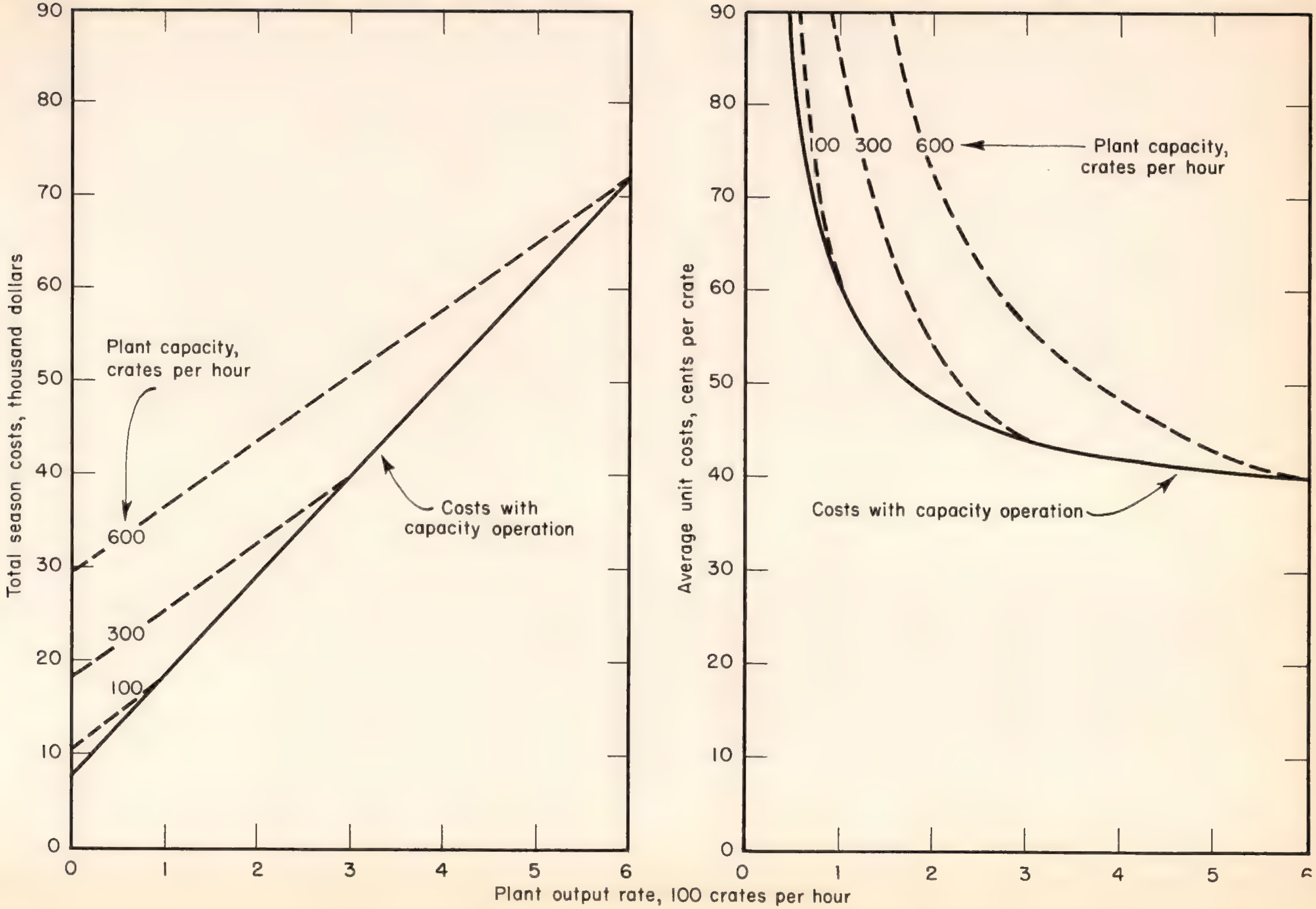

Figure 23. Costs Of Packing Fresh Plums In The Standard Crate At Less Than Plant Capacity Output Rate As Compared With Costs At Capacity Output Rate In Plants Operating 300 Hours Per Season And Packing Field Fruit Having 20 Per Cent Culls. California, 1955.

difference is shown to increase as the difference between design capacity and realized output rates in a particular plant increases.

Effect of Packaging Method on Costs

In the above, costs in relation to plant output rate, hours of operation per season, and per cent of culls have been compared in regard to place-packing the standard plum crate. Similar relationships, but at a lower level, could be demonstrated with respect to place-packing the test carton or bulk-filling either type of container. Details of such additional comparisons are omitted. This leaves still to be considered a central problem in this study--the effect of packaging method on costs. Two aspects of this problem are potentially significant. These are the effect of packaging method on the costs of packing house operations and its effect on the costs of container materials and assembly.

Effect of Packaging Method on Packing House Costs

The effect of method of packaging on total plant and average unit costs is demonstrated in Figure 24. The cost relationships shown in this chart are based on equations of total season cost in relation to plant output rate given in Table 24 with respect to plants operating 300 hours per season with a culling rate of 20 per cent. As in the preceding demonstrations, the level of unit cost is shown to be substantially less in large as compared with small plants. Also--when expressed on a crate-equivalent basis--costs in place-packing cartons are considerably less than in place-packing crates and they are still lower with the bulk-fill packaging method. In a plant of 500 crates per hour capacity, for example, total season cost (exclusive of container costs) is $61,000 with the standard crate, $53,000 with the carton, and $37,000 with bulk fill. The corresponding unit costs are 40.6, 35.3, and 24.7 cents per crate equivalent. Similar differences prevail at other output rates shown in Figure 24 and would also be found in comparisons based on different lengths of season and per cent of culls.

The reduction in packing house operating costs in packing cartons as compared with crates is due primarily to lower costs of place-packing a crate equivalent in the carton and to lower costs--primarily with respect to car bracing materials--in loading cartons as compared with crates. A still greater reduction in cost with cartons would be indicated if a container size equal in net-weight capacity to the crate were used. This would require the handling of smaller quantities of materials and packed containers and hence would lower slightly the labor requirements

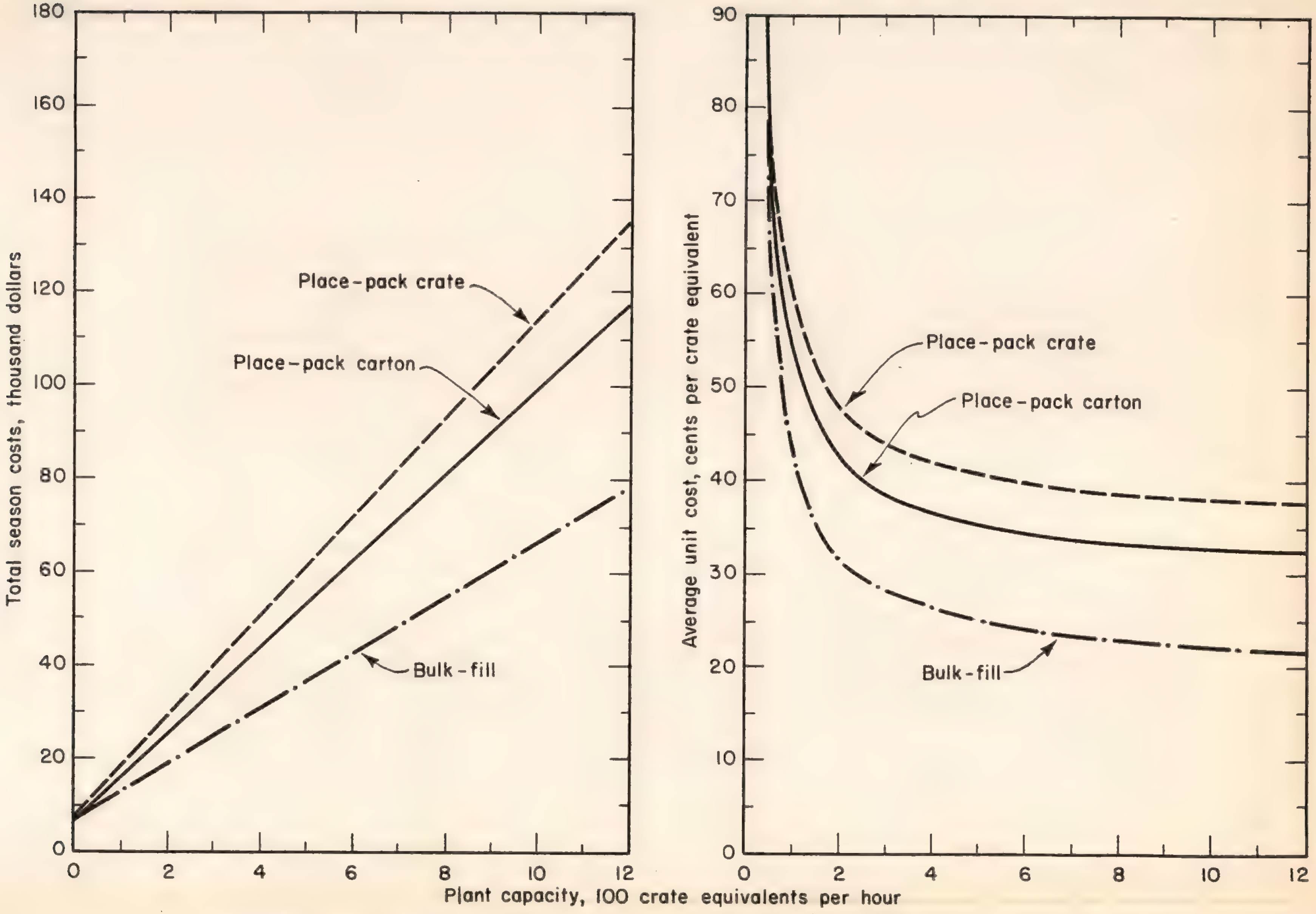

Figure 24. Total Season Costs and Average Cost Per Crate Equivalent of Packing Plums in Relation to Rate of Plant Output and Method of Packaging; 300-Hour Season, 20 Per Cent Culls. California, 1955. (Cost of Container Materials Not Included.)

and costs of these operations with cartons as compared with crates. The relatively low level of costs with the bulk-fill method as compared with place-packing either the crate or carton is attributable to the greatly reduced labor requirement and cost of filling the container with bulk methods.

Effect of Packaging Method on Container Costs

To complete the foregoing cost comparisons, consideration must be given to the costs of the container materials. Table 26 givestypical materials costs for the standard crate as well as similar costs for two types of test carton when purchased in lots of 15,000 containers.[1] The unit cost of materials per container is shown to be appreciably less with the carton than with the crate. When cost per carton is converted to a crate-equivalent basis in terms of the weight of fruit packed, an appreciable cost advantage with the carton remains. Substantial reductions in the cost of container materials can be made, therefore, by place-packing or bulk-filling plums in the carton.

Effect of Packaging Method on Component Costs

This section summarizes the results of the detailed cost comparisons given above. This is done in terms of costs with a plant capacity of 300 crates per hour and an operating season of 300 hours--the most common plant size and length of season in the plants studied.

From the plant costs developed in preceding sections, unit costs per crate equivalent are determined for place-packing the crate, place-packing the carton, and bulk-filling the carton. Unit costs for these three methods of packaging are shown in Figure 25. Four major cost components are given: (1) package materials; (2) labor; (3) annual charge for equipment and buildings; and (4) administrative and general expense. Package materials cost is an important item, amounting to 45.7 cents per crate and 39.2 cents per carton (figured on a crate equivalent basis). Container costs accounts for over one half of total packing cost. Labor is the second most important item of cost, amounting to 26.4 cents with the standard crate, 22.5 cents with the place-packed carton, and 12.7 cents with the bulk-filled carton. Smaller differences are noted for the annual charge for equipment and buildings while the administrative and general expense component is the same and cost of these operations [illegible] Figure [illegible]. The [illegible] of costs with [illegible] method [illegible] [illegible] to the [illegible] labor [illegible]

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[1] Shipments of the test carton were not in large volume, and the containers were of an experimental type. Somewhat different materials prices might have been experienced if the cartons had been of standard design, purchased in large volume.

[illegible]

The [illegible] of the foregoing [illegible], could [illegible] to [illegible] the [illegible] of the production [illegible]. Table [illegible] of standard [illegible] [illegible]

[illegible]

This section compares the [illegible] of [illegible]. [illegible] of 8.1 [illegible] and an operating season of 500 [illegible] plant size and [illegible] season [illegible].

For the [illegible], unit costs [illegible] (1) [illegible] (2) labor, (3) [illegible] and buildings; and (4) [illegible]

[illegible]

TABLE 26

Materials Cost of Different Types of Containers Used.
Packaging California Plums, 1955

Type of package	Materials cost per unit	Materials cost per crate equivalent
	dollars	
Standard crate[a]	.457[b]	.457
Test carton[c]		
8B-29 (full telescope lid)	.375[d]	.420[e]
9B-24 (self-locking lid)	.350[d]	.392[e]

[a] Includes the cost of container insides--baskets, shims, collars, and liners--as well as the lid.

[b] Average costs of materials obtained from plant accounting records.

[c] Includes the cost of container, pad, and tray.

[d] Estimated package materials costs for purchases in lots of 15,000 containers, 1955.

[e] Based on net weights of 28 pounds for the crate and 25 pounds for the carton.

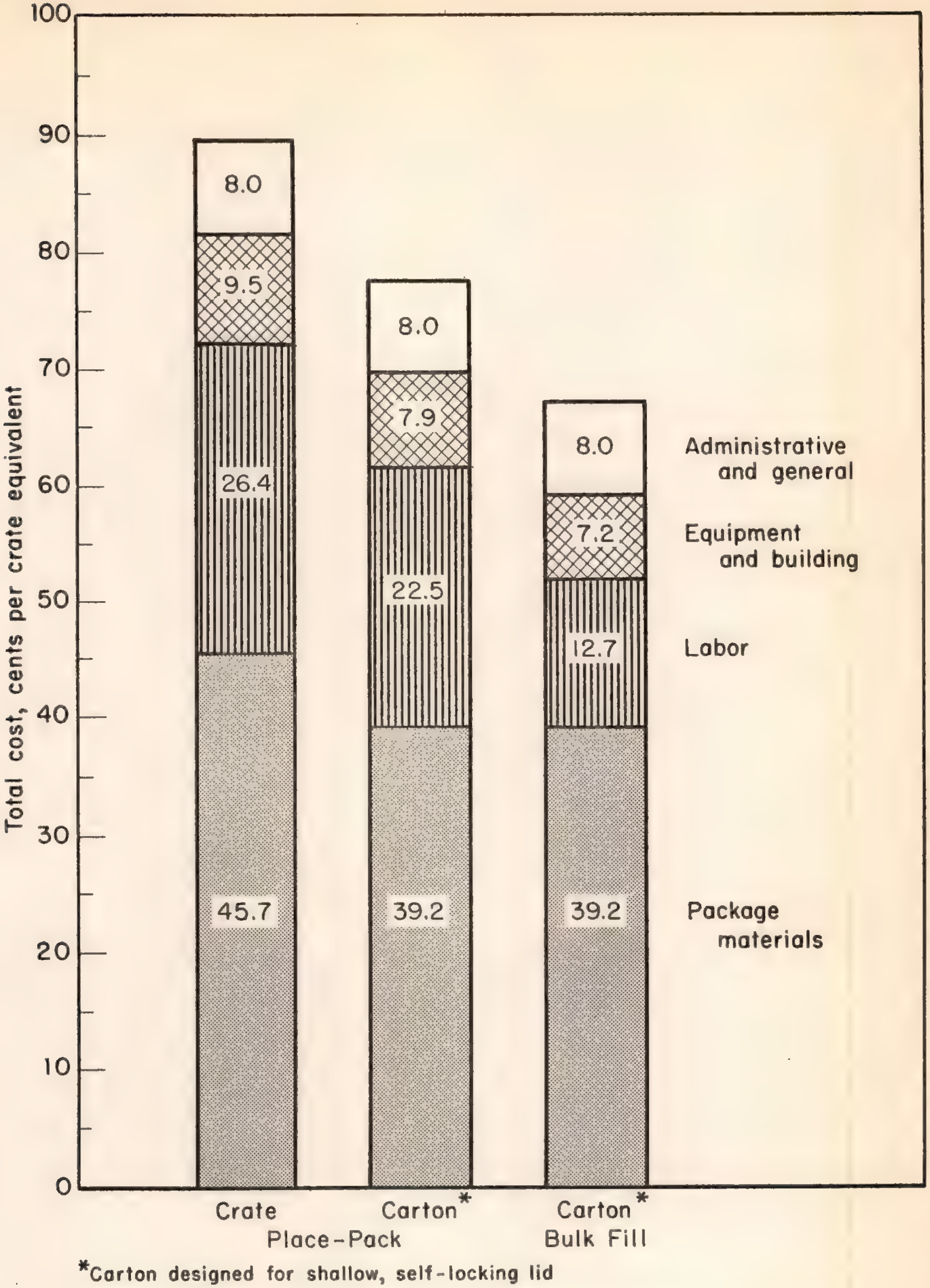

Figure 25. The Effect of Type of Container and Method of Fill on Total Unit Cost of Packing Fresh Plums in Plants of Capacity Rate of 300 Crate Equivalents Per Hour, Operating 300 Hours Per Season, and With 20 Percent of the Total Fruit Run Removed as Culls, California 1955.

for each packaging method. Total unit packing costs per crate equivalent amounts to 89.6 cents for place-packing the crate, 77.6 cents for place-packing the carton, and 67.1 cents for bulk-filling the carton.

The above cost comparisons indicate that substitution of the place-packed carton for the standard crate results in savings of 12.0 cents per crate equivalent. Approximately 6.5 cents of this saving is in container costs, while labor and other costs are reduced 5.5 cents per crate equivalent. By bulk-filling plums in the carton, the savings as compared with place-packing the standard crate are 22.5 cents per crate equivalent. This includes reductions of 6.5 cents in container costs, 13.7 cents in labor costs, and 2.3 cents in other costs.

FRUIT QUALITY AND PRICES RECEIVED IN RELATION TO PACKAGING METHOD

While this study has emphasized the effect of container type and packaging method on costs, other tests of trade acceptability must be met. The most important of these are effect on sale price and quality of fruit on arrival at the terminal market. These aspects of the problem were not observed directly in the study, but some evidence is available from other work.

Effect on Fruit Quality

Comparisons as to quality of fruit shipped in cartons as compared with crates were obtained in five test shipments to the Chicago and New York Auction Markets.[1] Inspection certificates of the U. S. Department of Agriculture relative to these shipments indicated that the average percentage of plums sustaining "slight bruising"--defined as a flattening of the surface by pressure not serious enough to affect grade--was 11.7 per cent in the experimental container and 7.8 per cent in the standard crate. Damage by "bruising" averaged 2.9 per cent in the experimental containers and 1.4 per cent in the standard crate. Serious damage to the fruit averaged 1.0 per cent in the experimental containers and 0.4 per cent in the standard crate. Decay averaged 0.6 per cent in the experimental container and 0.4 per cent in the crate.

In a second series of tests two modifications of the test carton design were made in an effort to reduce damage by bruising. These involved replacement of the rigid cardboard tray by a more flexible tray of molded pulpboard and increase in depth of container to 7 inches to reduce damage from overpacking sometimes necessary to reach the desired net weight of 25 pounds. Terminal market inspection of

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[1] Pilz, Barry, and Stokes, op. cit., p. 31.

test shipments with the modified containers indicated an increase in the average percentage of "slight bruising" but that damage by "bruising" was sharply reduced. Data concerning comparable shipments in the standard crate were not reported for the second series of tests.

The above data as to the effect of packaging method on quality were obtained in studies of place-packed containers. No direct observations of arrival condition of containers packed with the bulk-fill method are available. Simulated transit tests of bulk-filled containers packed with pears, however, indicate that favorable results with this method of packing pears might be expected.[1] Similar success with bulk-fill methods of plum packing is not unlikely.

Effect on Prices Received

Two series of price comparisons were attempted with reference to test shipments of place-packed cartons to the New York Auction. In the first of these, during 1955, the prices received for the most nearly comparable size of fruit found in the two containers--the 4 x 5 crate and the 7-row carton--indicated that in 4 of a total of 11 sales compared, fruit in the carton sold at a higher price per pound than in the standard crate, while in the remaining 7 sales crate-packed fruit sold at a higher price per pound.[2] In the second series of tests, a total of eight price comparisons were obtained, two of which indicated a higher price received per pound for carton-packed plums while six sales resulted in a higher price per pound for crate-packed plums.[3]

In reporting the above results, difficulty was recognized in obtaining price information on sales of fruit in the two types of container that were comparable from the standpoint of time of sale, variety and size of fruit, quality of fruit at the time of packaging, and uniformity of shipping conditions. Some of the variation in prices obtained with the two types of container may have been attributable to inability to completely standardize the sale conditions described. An additional factor, not evaluated, is the effect on price of the difference in volume of fruit offered in the two types of container and in the degree to which they had been established as a conventional container.

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[1] Sommers, Noel F., "Pear Transit Simulated in Test," California Agriculture, vol. 11, no. 9, September, 1957, p. 3.

[2] Pilz, *et al.*, op. cit., pp. 38-41.

[3] California Tree Fruit Agreement, California Tree Fruit Agreement (Sacramento: 1955 and 1956), Tables 1-13.

INDUSTRY SAVINGS

This section considers the industry savings that can be made by: (1) adopting a less costly packaging method; (2) adopting improved techniques at other stages; and (3) consolidation into larger plants operating more hours per season.

Savings with New Packaging Methods

Complete evaluations of new packing methods requires consideration of the effects on returns as well as on costs. Information on the quality and prices received for fruit packed in the different types of containers, however, is sparse and cannot be adequately standardized. This necessitates a comparison of the different containers on the basis of cost only and amounts to an assumption of equal returns per pound of fruit of a given size sold in the different containers.

Savings in cost with new packaging methods are based on the costs given in Figure 25. These unit packing costs amount to 89.6, 77.6, and 67.1 cents per crate equivalent for place-packing the crate, place-packing the carton, and bulk-filling the carton respectively. The cost savings in place-packing plums in the carton, compared with the standard crate, amount to 12.0 cents per crate equivalent. Cost savings in bulk-filling plums in the carton compared with the crate amount to 22.5 cents per crate equivalent. On the basis of average yearly volume of 4,500 cars of plums shipped interstate in 1954 to 1956, industry savings would amount to $540,000 per year with the place-packed carton and $1,012,500 per year with the bulk-filled carton. Most of these savings could be made the first year, but some of the savings would not be effective until equipment items used with the crate need to be replaced.

Savings With Other Methods Improvements

Although the plants studied were using the low-cost methods at most stages, further savings could be made by adopting least-cost methods at all stages. Lack of complete data on actual costs in a number of plants, however, prevents accurate estimation of these savings.

Savings Through Plant Consolidation

If each packinghouse were efficiently using the low-cost methods at each stage of operation, further savings would be possible for the industry by the

consolidation of smaller plants into fewer and larger plants, operating more hours per season. In most areas this consolidation would be possible without substantial increases in the cost of transportation from the orchard to the packinghouse because of the concentration of plum production and packing in certain areas. Since there is unlikely to be much consolidation of the output in ranch-pack plants--because of other cost advantages in this type of small plant--and in areas of sparse production, the average savings in cost per crate equivalent through consolidation are applied to only 80 per cent of industry volume.

To estimate the savings from consolidation, plants were classified into three groups with capacities in crate equivalents per hour as follows: (1) under 200; (2) 200 to 399; and (3) 400 and over. Plants in the first group include about 24 per cent of sample volume. If this first group, with average capacity of about 140 crate equivalents per hour, could be consolidated into plants of about 400 crates per hour, industry savings of 11.3 cents per crate or $98,400 per year can be made. Plants in the second group pack about 47 per cent of the industry volume. If plants in this group, with average capacity of about 250 crates per hour, are consolidated into plants of about 500 crates per hour capacity, estimated industry savings amount to 5 cents per crate or $85,000 per year. No consolidation was assumed for plants in the third group with capacities of 400 crates per hour or more.

Additional savings could be made by further consolidation and an increase in the number of hours operated per season to handle the larger volumes. For example, the number of hours per season might be increased from the industry average of about 300 hours to 450 to 500 hours per season by double-shift operation. If this were accomplished, savings would amount to 6.6 and 6.2 cents in consolidated plants of 400 and 500 crates per hour capacity respectively. Potential industry savings from this increase in length of season would amount to $57,500 and $105,300 for the two plant-size groups described above.

Thus, total potential savings from consolidation into larger plants with more hours of operation per season amount to $346,200 per season or about 7.7 cents per crate on industry volume of 4,500 cars per year. These estimated savings from consolidation are for plants packing the standard crate. Approximately the same savings could be made in plants place-packing or bulk-filling the fiberboard carton.

The full amount of the estimated potential savings from plant consolidation could not be realized immediately. This could be accomplished only if the equipment and buildings had alternative uses or as they wore out and were replaced by larger plants.

Total Potential Savings

Savings from plant consolidation can be made irrespective of the type of container packed. This amounts to about $346,000 per year or 7.7 cents per crate on industry volume. If these savings are added to the savings of place-packing or bulk-filling the fiberboard container, yearly industry savings could amount to $886,000 and $1,359,000 respectively or 19.7 and 30.2 cents per crate equivalent on industry volume of 4,500 cars per year.

SUMMARY

A large proportion of California plum production is shipped fresh to eastern markets. In most such shipments, the fruit is place-packed in the standard four-basket crate. Because of the transport distances, method of packaging, and quality of package required, costs are high. Over a short period they also are relatively inflexible. Thus, during periods of low market price for plums, these costs bear with special force on producers. Important aspects of the packing cost are the expense of container materials and labor and equipment costs of filling the containers. This study is aimed at determining how the costs of packaging and other packinghouse operations are affected by the methods used, rate of output, length of season, and rate of culling as a step toward reducing the cost of these operations.

Cost comparisons are made in terms of estimated costs based on economic and engineering data obtained in studies of actual plant operations. Within given plant stages, separate calculations are made with respect to each of the various methods available. The results permit determination of the relative costs of the various methods and selection of the most efficient method and cost of handling a given volume of fruit in any plant stage as well as the total cost involved in integrated operation of a complete plant. Separate plant cost relationships are developed for each of three methods of packaging--place-packing the standard crate, place-packing a fiber board carton, and bulk-filling a fiberboard carton.

The studies show in general that mechanized methods become more economical as plant size and length of operating season increase. For example, over the range of plant size and hours of operation per season applicable in plum packing, hand truck equipment is shown to be more economical than fork truck equipment for inplant transportation activities. Conveyor equipment, however, is shown to be more economical than hand trucks in the transportation of packed fruit and culls in plants of moderate to large size and with operating seasons of

length frequently exceeded in California plants. Similarly, mechanized methods of container fabrication and supply to packing stations become economical in plants of relatively large capacity and long operating season. This applies also to other types of equipment used with each type of container and packaging method considered and in other aspects of plant operation.

Total plant cost relationships developed with respect to any given type of container are used to demonstrate the extent to which costs in efficiently organized plants are affected by scale of output, hours operated per season, and per cent of culls. For example, in place-packing the standard crate in a plant operating 300 hours per season with a culling rate of 20 per cent, costs per package--including the cost of container materials--are 93.7 cents in a small plant of 200 crates per hour capacity. But in a plant of 700 crates per hour capacity, they are only 84.8 cents per crate, while in a plant of 1,200 crates per hour capacity, they are 83.4 cents per crate. Large plants thus enjoy a substantial cost advantage over small plants. This effect is most significant in the range of small plant size and becomes progressively less important as plant size increases.

If operations such as the above are considered in a plant of given capacity rate, but with length of season variable, the effect of this variation on costs can be determined. In a plant of 500 crates per hour capacity, for example, total cost per crate in a season of 100 hours' operation is $1.16. With 300 hours' operation, the cost per crate is only 84.8 cents, and with 500 hours' operation it is 80.0 cents per crate. The decreasing costs are attributable to spreading fixed costs in a plant of given size over larger total season volumes as hours operated increase. A substantial handicap is indicated for plants with short-season operation, a situation that can be relieved by packing other commodities maturing in other periods and using essentially the same equipment. The effect decreases rapidly, however, as length of season increases and is not of great significance in plants operating 500 or more hours per season. Costs are shown to increase progressively as the proportion of culls increases. With a 300 hour season and a plant capacity of 500 crates per hour, for example, a reduction in cull percentage from 20 to 10 per cent would reduce costs per package by about 1.5 cents, while an increase to 40 per cent culls would cause costs per package to rise by about 4.5 cents above the level with 20 per cent culls.

Comparisons of costs with different packaging methods--when based on cost per crate equivalent--indicate substantial savings with bulk-fill as compared with alternative methods of place-packing. Thus in a plant of 500 lugs per hour

capacity operating 300 hours per season with 20 per cent culls, total cost per crate equivalent with the bulk-fill packaging method are 63.9 cents in a fiberboard container as compared with 74.5 cents in place-packing the carton and 86.3 cents with the standard crate. Savings with the carton as compared with the crate-pack include a reduction of 6.5 cents in the costs of container materials.

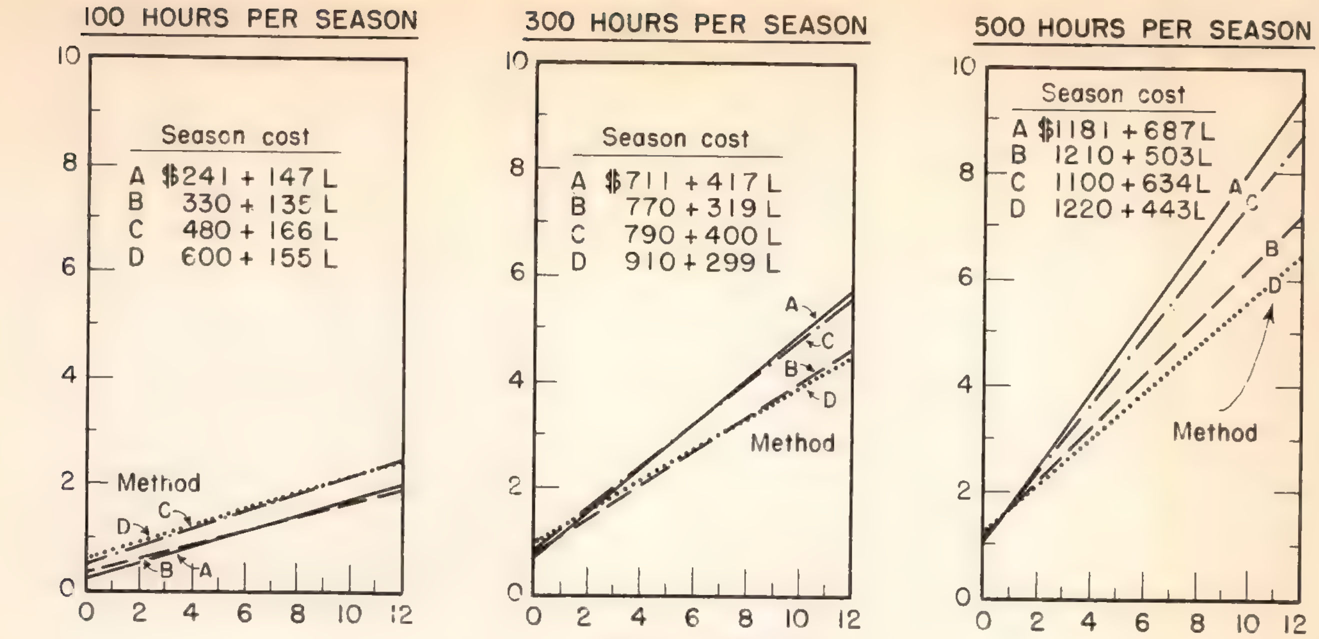
Other aspects of the problem involve evaluation of the effect of alternative types of container on fruit quality and price in the terminal market. While not specifically covered in this report, some indications relative to these questions are available in other studies. Test shipment experience and laboratory transit tests both have suggested that place-packed cartons or bulk-filled containers can deliver plums of quality equal to that obtained with the standard crate. Evidence from other studies relative to prices received in the terminal market indicates mixed results. Some price advantage is indicated with sales of fruit packed in the standard crate, but the evidence is not conclusive particularly from the standpoint of relative prices that might be expected to prevail if carton-packed fruit were regularly available in the market in large volume.

Potential savings in packinghouse cost were estimated in two areas: (1) savings through the adoption of improved containers and methods of packaging, and (2) savings through consolidation of plants.

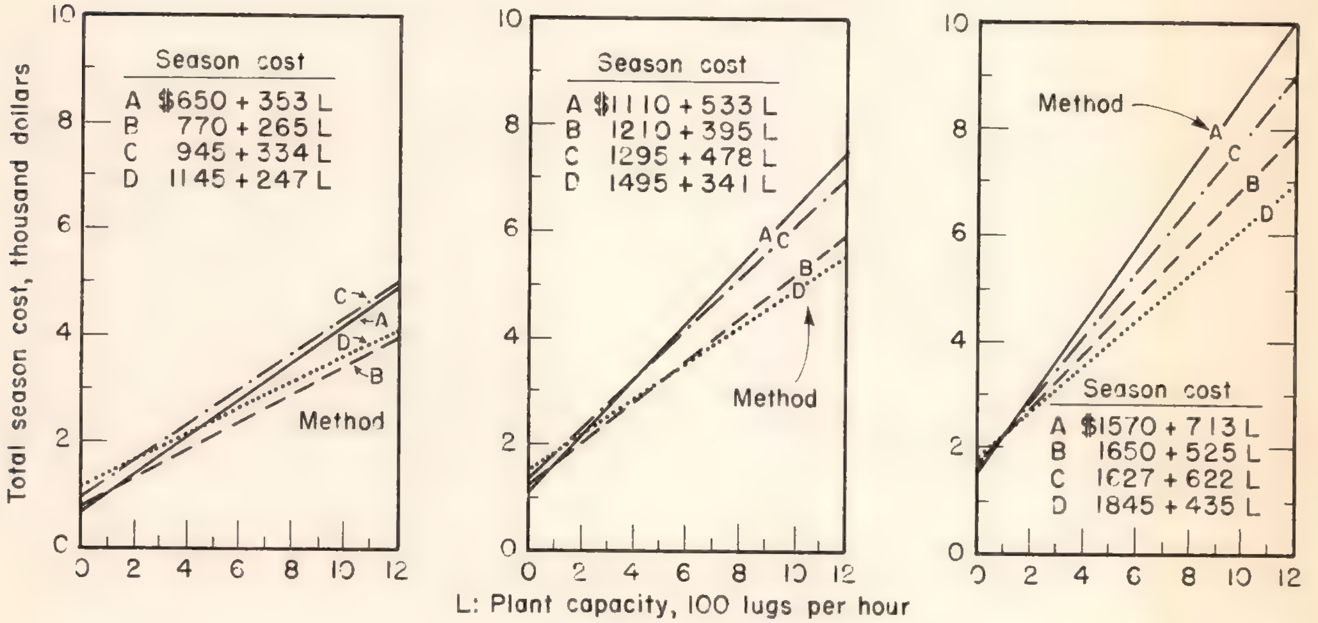
On the basis of equal returns per pound of fruit sold in the different containers, and for a plant size of 300 crates per hour and a 300-hour season, a saving of 12.0 cents per crate equivalent is indicated in place-packing plums in a fiberboard container as compared with the standard crate. If the plums are bulk-filled in a fiberboard container, savings of 22.5 cents per crate equivalent might be realized. If applied to the average yearly volume of plums moved in interstate shipment in 1954 to 1956, these savings would amount respectively to $540,000 and $1,012,500 per year.

Potential savings from consolidation into larger plants would amount to $183,400, while gains from further consolidation by increasing the hours of operation per season in these larger plants would amount to $162,800. Total industry savings from consolidation would amount to $346,200 or about 7.7 cents per crate on average interstate volume in 1954 to 1956.

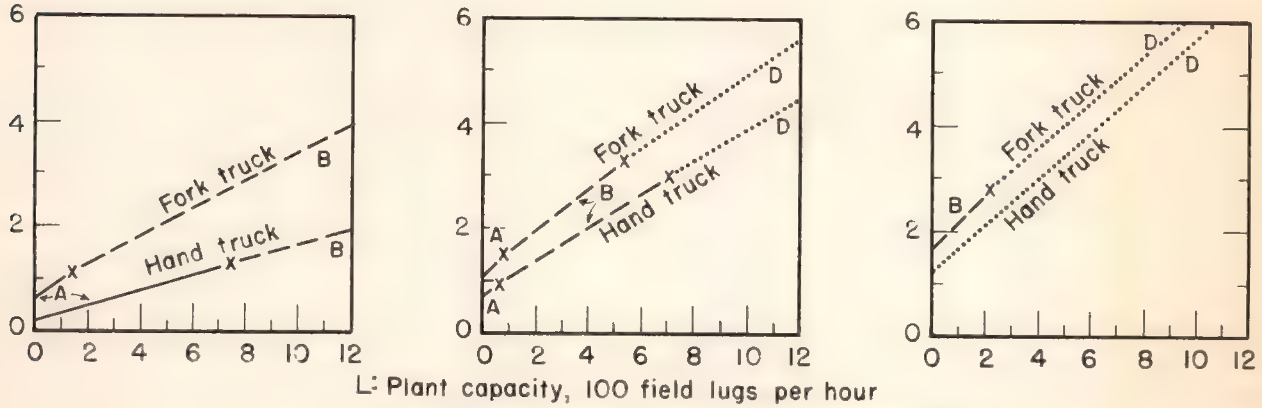
Gains from consolidation can be made irrespective of the type of container packed. If these savings are added to those possible by a change in container and packaging method, the totals would amount to $886,000 for the place-packed carton and $1,359,000 for the bulk-filled carton or 19.7 and 30.2 cents per crate equivalent.



A. HAND TRUCK



B. FORK TRUCK



C. COMPARISONS, LOW COST METHODS

Appendix Figure A. Total Season Cost Of In-plant Transportation In Hand Truck And Fork Truck Plants Using The Carton As The Packed Fruit Container, Shown In Relation To Capacity Rate Of Plant Output, Length Of Operating Season, And Transportation Method Used. Packing California Fresh Plums, 1955.

APPENDIX TABLE A

Net Time Requirements for Transportation with Warehouse - Type Trucks, Minutes Per Round Trip

Type of equipment and job	"Turn-around" time	Travel time[a]
	minutes	
Hand Truck		
Unload highway truck[b]--Full field lugs to storage or dumper and empty cannery lugs to storage or cannery set-off.	0.311	0.00659D
Transport to highway truck or car[b]--Empty field lugs from storage or dumper, full cannery lugs from cannery set-off or storage, and packed fruit from lidder set-off or from storage.	0.339	0.00659D
Transport from storage--Full field lugs to dumper, empty cannery lugs to cannery set-off, empty packing boxes to box liner.	0.274	0.00659D
Shook to boxmaker.	0.365	0.00620D
Transport to storage--Packed fruit from lidder and full cannery lugs from cannery set-off.	0.292	0.00676D
Empty packing boxes from boxmaker.	0.274	0.00676D
Empty field lugs from dumper.	0.236	0.00676D
Fork Truck		
Unload highway truck		
Full field lugs to storage or dumper.	0.805	0.0050D
Empty cannery lugs to storage or cannery set-off.	0.760	0.0050D
Load highway truck		
Empty field lugs from storage or dumping station.	0.617	0.0050D
Cannery lugs from storage or cannery set-off.	0.765	0.0050D
Transport from storage		
Packed fruit to car and full field lugs to dumper.	0.688	0.0050D
Empty cannery lugs to cannery set-off, shook to boxmaker, and empty packing boxes to packer supply point.	0.538	0.0050D
Transport to storage		
Empty field lugs from dumper and empty packing boxes from boxmaker.	0.513	0.0050D
Packed fruit from lidder set-off and cannery fruit from cannery set-off.	0.688	0.0050D
Powered Hand Truck		
Transport to and from storage points--Field lugs, cannery lugs, packed fruit, shook, and empty packing boxes.	0.690	0.0053D

[a] D = one-way distance in feet.

[b] Distance measured from delivery or pickup point in packing house to edge of truck.

Source: Sammet, L. L., In-Plant Transportation Costs as Related to Materials Handling Methods--Apple and Pear Packing (Berkeley: University of California, Division of Agricultural Sciences, Agricultural Experiment Station, 1953), p. 53. (Giannini Foundation Mimeographed Report No. 142.)

APPENDIX TABLE B

Selected Job Descriptions and Labor Production Standards in Plum Packing Operations. California, 1955[a]

Job description	Unit[b]	Net time	Gross time[c]	Production standard
		minutes		units per hour
Dump field lugs				
Hand dumping--Get field lug from stack on floor, transfer to dump stand, empty lug, and restack on floor.	field lug	.137	.171	350
Hand dumping with conveyor aids--Pull field lug from set-on conveyor to dump stand, empty lug, and place on empty lug conveyor.	field lug	.104	.130	460
Set on--Get field lug from stack on floor and place on conveyor to dumper.	field lug	.104	.130	460
Set off--Receive empty lug on conveyor from dumper and stack on floor.	field lug	.082	.103	585
Handle culls				
Fill cull lug--Take empty lug from stack on floor and place at cull collection point, fill and level fruit in lug, and stack full lug on floor.	field lug	.267	.334	180
Dump culls--Get cull lug from stack on floor, empty cull fruit into road truck, and stack empty lug.	field lug	.148	.185	325
Make containers				
Manual--Place crate ends into simple jig or stand, manually nail crate bottom pieces and sides to ends, aside completed crate, and obtain crate materials from nearby storage.	crate	.919	1.011	59
Stitcher machine--Assemble crate materials into machine, operate machine through three nailing cycles, and set crate aside.	crate	.218	.240	250
Standard machine--Assemble crate materials into nailing machine, operate machine, and set crate aside.	crate	.127	.140	430
End feed machine--Assemble crate sides and bottom pieces into a machine that automatically feeds the crate ends and nails the crate bottoms or crate side on successive cycles of the nailing head.	crate	.109	.120	500
Supply shook--Transport crate or materials from temporary storage to crate maker as needed.	crate	.100	.120	500
Make telescope carton--Manually fold carton bottom and telescoping lid and stack nearby. Obtain bundles of carton materials from nearby storage.	carton	.990	1.188	51
Staple carton				
Obtain collapsed carton material from adjacent bundle, fold carton, staple bottom flaps, and aside.	carton	.180	.216	280
Fold down top edges of carton bottom, insert carton liner, and stack on floor or pallet; fold shallow carton lid and obtain carton supplies for stapler.	carton	.528	.633	95
Total for stapled carton.	carton	.708	.849	71
Supply containers				
Set off and stack container from container maker.	[d]	.054	.060	1,000
Transfer empty container from conveyor to elevator, to supply chute, or to monorail hook.	[d]	.063	.070	860
Transfer empty container from conveyor to adjacent temporary storage.	[d]	.082	.090	670
Return emtpy container from adjacent temporary storage to conveyor.	[d]	.082	.090	670
Set containers on adjustable basement elevator and adjust elevator level.	crate	.071	.078	770
Direct clerical				
Stamp size and net weight, stamp lot and variety on one side of container, place top pad, tally number of containers by size by grower, or tally number packed by each packer.				
One of the above jobs.	[d]	.071	.088	680
Two of the above jobs.	[d]	.110	.138	435
Three of the above jobs.	[d]	.166	.207	290
Container closing				
Manual lidding--Manually nail lid on crate while lid is held in place by a press-type machine.	crate	.578	.642	95
Stitcher lidding--Place lid on crate and operate machine which drives one nail at a time in each end of the lid as the crate is pushed through the machine.	crate	.150	.183	330
Standard lidding--Push packed crate into the machine, insert lid, and press a foot pedal to operate the machine.	crate	.105	.129	460
High-speed lidding--Feeds in lid (machine does the rest--carries the crate into the machine, lids, and ejects).	crate	.065	.080	750
Carton closing--Place shallow lid on carton and push down until it hooks on to the flaps on the filled carton.	carton	.234	.293	205
Carloading				
Crate--Prepare car for loading, transfer 1,000 crates from conveyor or hand truck to stack in car, get and place gate, fabricate and place door bracing material, and squeeze load.	crate	.234	.293	205
Carton--Prepare car for loading, transfer 1,100 cartons from conveyor or hand truck to stack in car (solid load requires no gates or bracing materials).	carton	.126	.157	380

[a] Includes unit times and production standards not given in the body of the report.

[b] The approximate average net weights of filled containers are as follows: Field lug--36 pounds; field lug filled with culls--40 pounds; crate--28 pounds; and carton--25 pounds. The approximate inside dimensions are as follows: Field lug--24" x 14" x 7"; crate--16" square and 4 1/2 to 6 inches deep depending on size of fruit packed; carton--13" x 13" x 7".

[c] Includes allowance for scheduled rest periods (approximately 4 per cent of total time) and minimum unavoidable delay.

[d] No difference with respect to type of packed fruit containers.

APPENDIX TABLE C

Replacement Cost and Percentage Annual Fixed Cost of Selected Equipment Items and Buildings. Packing California Plums, 1955

Item	Selected use life	Annual fixed cost as percentage of replacement cost		Replacement cost, 1955[b]
		Depreciation	Total[a]	
	years	per cent		dollars
Transportation and related jobs				
Fork truck plus 175 pallets[c]	10	10.0	16.5	5,100
Hand truck	15	6.7	13.2	90
Power conveyor				
Wood rollers	15	6.7	13.2	290 + 9.57L
Steel rollers	15	6.7	13.2	290 + 12.64L
Gravity conveyor				
Side wheel				
Regular	20	5.0	11.5	4.00L
For carloading	20	5.0	11.5	5.00L
Steel roller	20	5.0	11.5	7.50L
Cull conveyor	10	10.0	16.5	290 + 8.33L + 0.339WL
Cull elevator	10	10.0	16.5	290 + 9.15L + 0.427WL
Cull bin	15	6.7	13.2	3.00 per cubic foot
Dumping				
Dumping stand	15	6.7	13.2	40
Single-lug machine dumper	15	6.7	13.2	1,300 to 3,050
Stack machine dumper	15	6.7	13.2	2,590 to 4,470
Presizer	15	6.7	13.2	2,000
Grading				
Grading table	12	8.3	14.8	300 + 30L
Distribution belt	12	8.3	14.8	28L
Container making				
Crate				
Manual stand or jig	20	5.0	11.5	50
Stitcher machine	15	6.7	13.2	1,850
Standard machine	15	6.7	13.2	3,590
Automatic end-feed machine	15	6.7	13.2	4,860
Carton				
Stapling machine	15	6.7	13.2	500
Work bench	15	6.7	13.2	25
Container supply				
Chute from mezzenine to packing line	15	6.7	13.2	120
Conveyor to packers				
Gravity, two-level side				
Side wheel	15	6.7	13.2	8.00L
Roller	15	6.7	13.2	12.00L
Monorail	15	6.7	13.2	410 + 5.30L
Elevator				
Inclined slide, chain type	15	6.7	13.2	540
Cross-bar type, basement	15	6.7	13.2	665
Direct clerical				
Tally desk and materials	15	6.7	13.2	15
Stamp stand and stamps	15	6.7	13.2	20
Lidding				
Press-type manual lidder	20	5.0	11.5	120
Stitcher machine	15	6.7	13.2	1,850
Standard machine	15	6.7	13.2	2,350
High-speed machine	15	6.7	13.2	4,000
Carloading				
Car squeeze	15	6.7	13.2	840
Loading ramp	15	6.7	13.2	60
Miscellaneous equipment				
Minor tools and equipment	15	6.7	13.2	[d]
Field lug	10	10.0	17.0	.80
Buildings, wood frame	33	3.0	10.5	8,503 + 1.684A

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a/ Includes depreciation plus the following expressed as a percentage of replacement cost: Fixed repair (which allows for deterioration related to time)--1.5, except 2.0 allowed for buildings and field lugs; insurance--1.0, except 1.5 allowed for buildings; taxes--1.0; and interest on investment--3.0 (interest at 3.0 per cent equal to approximately 5.0 per cent on the undepreciated balance).

b/ In this column L = length of conveyor or belt in feet, W = width of conveyor or belt in inches, and A = building floor area in square feet. Replacement is given on the basis of cost per single unit.

c/ Allows approximately 45 pallets per 100 field lugs plant capacity per hour.

d/ See Table 18 for an itemized list of the individual items and their replacement costs.

APPENDIX TABLE D

Equations of Annual Fixed Charge and Variable Cost Per Hour in Relation to Method and Type of Transportation Equipment, Per Cent of Cull Fruit, and Type of Packed Fruit Container. Packing California Fresh Plums, 1955[a]

Transportation method and type of equipment	Crates[b]						Cartons[b]	
	10 per cent culls		20 per cent culls		40 per cent culls		20 per cent culls	
	Annual fixed charge	Variable cost per hour	Annual fixed charge	Variable cost per hour	Annual fixed charge	Variable cost per hour	Annual fixed charge	Variable cost per hour
	dollars							
Hand truck								
Method A--Hand trucks used for all jobs.	6 + 10L	2.45 + 1.16L	6 + 11L	2.20 + 1.30L	6 + 11L	2.20 + 1.40L	6 + 12L	2.35 + 1.35L
Method B--Hand trucks used for all jobs except conveyor for transporting packed fruit to car.	105 + 48L	2.50 + .73L	110 + 43L	2.20 + .92L	120 + 35L	1.95 + 1.21L	110 + 43L	2.20 + .92L
Method C--Hand truck for all jobs except conveyor and elevated bin for cull disposal.	290 + 44L	1.45 + 1.19L	315 + 55L	1.50 + 1.10L	375 + 85L	1.40 + .97L	325 + 49L	1.55 + 1.17L
Method D--Hand truck for all jobs except conveyor for transporting packed fruit to car and for cull disposal.	440 + 70L	1.50 + .75L	445 + 83L	1.55 + .72L	490 + 112L	1.55 + .67L	445 + 83L	1.55 + .72L
Fork truck								
Method A--Fork trucks used for all jobs.	420 + 227L	2.60 + 1.75L	420 + 230L	2.25 + .88L	420 + 237L	2.30 + .98L	420 + 263L	2.30 + .90L
Method B--Fork trucks used for all jobs except conveyor for transporting packed fruit to car.	540 + 190L	2.60 + .51L	550 + 200L	2.20 + .65L	650 + 185L	2.80 + .78L	550 + 200L	2.20 + .65L
Method C--Fork truck for all jobs except conveyor and elevated bin for cull disposal.	740 + 240L	1.70 + .74L	760 + 239L	1.80 + .66L	890 + 257L	1.70 + .61L	770 + 262L	1.75 + .72L
Method D--Fork truck for all jobs except conveyor for transporting packed fruit to car and for cull disposal.	870 + 206L	1.70 + .48L	970 + 200L	1.75 + .47L	1,190 + 196L	1.90 + .39L	970 + 200L	1.75 + .47L

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a/ Equations for 10 and 40 per cent culls with crates as the packed fruit container were developed by the same means described for Tables 3 and 4.

b/ L = plant capacity output rate in 100 field lugs per hour.

APPENDIX TABLE E

Equations Relating Annual Fixed Cost and Variable Cost Per Hour to Rate of Output in 100 Crate Equivalents Per Hour with 10 and 40 Per Cent Culls for Plum Packing Costs that Vary with the Culling Rate.
Packing California Plums, 1955

Stage or cost component and methods	Stage or component cost equation[a]	
	Annual fixed cost	Variable cost per hour
	dollars	
	10 per cent culls	
Plant transportation		
Hand truck		
A--Hand truck, all jobs	6 + 9P	2.45 + 1.00P
B--Conveyor for packed fruit	105 + 41P	2.50 + .63P
C--Mechanical cull handling	290 + 38P	1.45 + 1.03P
D--Conveyor for packed fruit and culls	440 + 60P	1.50 + .65P
Fork truck		
A--Fork truck, all job	420 + 196P	2.60 + .65P
B--Conveyor for packed fruit	540 + 164P	2.60 + .44P
C--Mechanical cull handling	740 + 207P	1.70 + .64P
D--Conveyor for packed fruit and culls	870 + 178P	1.70 + .41P
Grading[b]	170 + 72P	1.75 + 1.26P
Dumping		
A--Hand dumping	3 + 2P	.53 + .26P
B--Hand dumping with conveyor aids	80 + 29P	1.80 + .56P
C--Single-lug machine dumper	185 + 54P	1.35 + .35P
D--Stack dumper	275 + 80P	.75 + .18P
Miscellaneous[b]	224 + 635P	[c]
Administrative and general[b]	2,026 + 1,537P	[c]
	40 per cent culls	
Plant transportation		
Hand truck		
A--Hand truck, all jobs	6 + 14P	2.20 + 1.81P
B--Conveyor for packed fruit	120 + 45P	1.95 + 1.57P
C--Mechanical cull handling	375 + 110P	1.40 + 1.26P
D--Conveyor for packed fruit and culls	490 + 145P	1.55 + .87P
Fork truck		
A--Fork truck, all jobs	420 + 307P	2.30 + 1.27P
B--Conveyor for packed fruit	550 + 240P	2.80 + 1.01P
C--Mechanical cull handling	890 + 333P	1.70 + .79P
D--Conveyor for packed fruit and culls	1,190 + 254P	1.90 + .51P
Grading[b]	195 + 126P	1.70 + 2.26P
Dumping		
A--Hand dumping	3 + 3P	.53 + .39P
B--Hand dumping with conveyor aids	80 + 44P	1.80 + .84P
C--Single-lug machine dumper	185 + 80P	1.35 + .53P
D--Stack dumper	275 + 119P	.75 + .27P
Miscellaneous equipment[b]	224 + 953P	[c]
Administrative and general[b]	2,026 + 2,305P	[c]

[a] Costs related to L--100 field lugs per hour--in the stage analysis were converted to costs related to P--100 crates per hour--in this table by multiplying the cost coefficient of L by 0.8642 for 10 per cent culls and 1.2963 for 40 per cent culls.

[b] No variation in method.

[c] Not applicable.